



BARTLETT BROOK FLOW RESTORATION PLAN

City of South Burlington, Vermont

October 1, 2016

Prepared for:

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I. Disclaimer

The intent of this plan is to present the data collected, evaluations, analysis, designs, and cost estimates for the Bartlett Brook Flow Restoration Plan (FRP) Project, completed under a contract between the City of South Burlington and the hired consultant team, Watershed Consulting Associates, LLC and Aldrich & Elliott, PC. The Bartlett Brook FRP was prepared to meet the compliance requirement for the Bartlett Brook impervious surface owners (the City of South Burlington, the Vermont Agency of Transportation (VTRANS) and the Town of Shelburne) under the National Pollutant Discharge Elimination System (NPDES) General Permit 3-9014 (VTDEC 2012) for stormwater discharges to impaired waters.

1. Executive Summary

This Flow Restoration Plan (FRP) for the Bartlett Brook watershed was developed in accordance with requirements in the Municipal Separate Storm Sewer System (MS4) General Permit #3-9014 (2012). Once approved by the Vermont Department of Environmental Conservation (VTDEC) this FRP will become part of the Stormwater Management Plans (SWMP) prepared by the MS4 permittees in the Bartlett Brook watershed. This includes the City of South Burlington, the Town of Shelburne, and the Vermont Agency of Transportation (VTrans). The Bartlett Brook FRP will act as a guidance document for the MS4 entities as they implement stormwater Best Management Practices (BMP's) over a twenty (20) year timeframe, in the effort to return Bartlett Brook to its attainment condition.

Development of the Bartlett Brook FRP was an iterative process that utilized the Vermont Best Management Practice Decision Support System (BMPDSS) model maintained by VTDEC. This model was created by VTDEC and its partners as part of the initial TMDL development. The BMPDSS model allows the user to add, remove, or modify information related to the existing and proposed stormwater BMPs in the watershed. The BMPDSS then predicts the impacts that these changes will have on stream flow. In 2002, VTDEC provided a "base" condition BMPDSS model for Bartlett Brook. This version of the BMPDSS model included all stormwater BMPs that existed in the watershed prior to 2002 and provided an estimated stream flow during the 1-year storm event. The goal of the FRP is to reduce stream flow by 33.0% during this target storm event.

The first step in FRP development was to inspect all existing BMPs included in the "base" condition model (Pre-2002). Based on the results of these field inspections, revisions were made to the BMPDSS model. Once this work was complete, the BMPDSS model was updated to include all BMPs that were constructed in the watershed after 2002. This version of the model became known as the "existing" conditions, or Post-2002, model run.

Following updates to the BMPDSS for the Pre-2002 and Post-2002 model scenarios, existing Pre-2002 BMPs were evaluated to determine if they could be retrofit to provide improved treatment and detention of stormwater runoff. After an initial list of retrofit sites were identified, a preliminary field assessment was completed at each site to document any potential constructability issues and review the drainage areas for each proposed BMP. These new BMPs were then incorporated into the BMPDSS model. New BMPs were added to the BMPDSS model until the required stream flow reduction target was achieved.

In addition to the identification of stormwater controls, the Total Maximum Daily Load (TMDL) flow targets and future growth assumption developed by the VTDEC was reviewed in the context of the FRP development. In February 2014, at the request of the City of South Burlington, the Chittenden County Regional Planning Commission (CCRPC)¹ completed a study to estimate the expected non-jurisdictional impervious area growth in the Bartlett Brook watershed over the

¹ Chittenden County Regional Planning Commission (CCRPC). 2014. Non Jurisdictional Impervious Surface Analysis for the Bartlett Brook Watershed.

next 20 years. The original TMDL arbitrarily assumed a non-jurisdictional impervious growth of 50 acres, whereas the CCPRC study estimated 5.7 acres based on the actual non-jurisdictional growth rate from 2003 to 2010. The revised future growth reduced the high-flow target (Q0.3%) from 33.0% to 11.6%². The modified flow target was incorporated into the FRP planning process and proposed BMP implementation scenario.

The final proposed BMPDSS model run that ultimately exceeded the required reduction in stream flow during the 1-year storm event includes a total of 18 sites—five (5) retrofits to existing BMPs, four (4) new detention systems, three (3) new infiltration systems, and six (6) green stormwater infrastructure (GSI) systems. The proposed BMPs were assessed with the BMPDSS model, and determined to address 194% of the modified TMDL high-flow target (Q0.3%). The total cost for implementation of the proposed plan is \$3,408,728.

Once the final list of required BMPs was determined, these projects were then ranked using a comprehensive matrix and scheduled for construction over a 17-year period. The MS4 permit requires that the BMPs identified in the FRP be constructed within 20 years of the effective date of the MS4 permit, which results in a December 5, 2032 deadline. Therefore, 17 years remain for project implementation prior to the construction deadline. A number of the BMPs are currently covered by expired State of Vermont stormwater permits. These BMPs were included at the front of the schedule so that the associated properties could complete the required stormwater improvements and achieve permit compliance. Other BMPs involve properties containing more than 3 acres of impervious area. VTDEC is currently drafting a “3 Acre Permit” that would require stormwater retrofit of these sites. Therefore, BMPs in this situation were also placed towards the front of the implementation schedule. Other BMPs are located on land owned or controlled by the MS4 entities. These BMPs were given priority over those that were located on private property. The remaining projects were scheduled based on their ability to contribute to stream flow reductions, cost effectiveness, and constructability.

The final step in FRP development was to develop a financial plan that would allow for the construction of the BMPs included in the BMPDSS model. The MS4s involved in the Bartlett Brook FRP worked together to develop an implementation schedule for Bartlett Brook. Some MS4s have responsibility for BMP implementation as part of FRPs in multiple watersheds. For example, the City of South Burlington has the responsibility to implement BMPs as part of FRPs in five stormwater impaired watersheds: Bartlett, Englesby, Centennial, Munroe, and Potash Brook. All five FRPs were considered when developing a comprehensive and realistic D&C schedule for the City. However, the design and construction schedule presented herein contains only the projects located within the Bartlett Brook watershed.

The top four (4) projects were selected for 30% engineering including 1) Bartlett Brook Central (BBC) infiltration gallery, 2) an infiltration basin along the Overlook Dr. walking path on the UVM Horticulture Farm, 3) an expansion of the Bartlett Bay Stormwater Treatment System (BBSTS) and 4) a retrofit to an existing stormwater pond on the Irish Farm Condos property covered under

² See Table 1: The Modified target was calculates as: $-(8.8\%) + (-24.4\%)*(5.7 \text{ ac}/50 \text{ ac}) = -11.60\%$

permit #1-1404. Preliminary 30% engineering plans were developed for the top four (4) priority projects with itemized planning level cost estimates. Sketch plans and spreadsheet based cost estimates were developed for all other proposed BMPs.

The City of South Burlington intends to finance the required stormwater BMPs by utilizing funds raised by stormwater utility fees, State and Federal grants, as well as low interest loan programs. Once projects were scheduled over the 17-year implementation schedule an annual 3% inflation rate was applied based on historic trends in the construction cost index. The City of South Burlington was then able to take these annual costs and insert them into their existing stormwater utility rate model. Three different scenarios were evaluated in the rate model. The first scenario assumed that grant funding would not be available and that the City would not utilize low interest loans to assist with project implementation. This scenario resulted in a stormwater billing rate of \$11.25 per Equivalent Residential Unit (ERU) in FY2032. The second scenario also assumed that grant funding would not be available, but that the City would utilize low interest loans to help pay for implementation of the projects. This scenario resulted in a stormwater billing rate of \$10.44 per ERU in FY2032. The third funding scenario assumed that grant funding of approximately \$250,000 per year would be available starting in 2018 and that this amount would increase to \$500,000 in 2030. This resulted in a stormwater billing rate of \$8.79 per ERU in FY2032.

2. Background

Bartlett Brook is currently on the State of Vermont's impaired waters list (EPA 303(d)) with the primary pollutant determined to be stormwater runoff. In the effort to restore Bartlett Brook and lift its impaired designation, a flow-based Total Maximum Daily Load (TMDL) was developed for Bartlett Brook. This TMDL requires reductions in stormwater flows during high flow conditions. Increases in stream baseflow were also recommended, but are not required under the TMDL. The flow targets are the basis for the FRP, developed in accordance with the Municipal Separate Storm Sewer System (MS4) General Permit Subpart IV.C.1 as a required part of the MS4s Stormwater Management Program (SWMP).

The purpose of the FRP is to outline a plan for the retrofit of existing impervious cover with stormwater management BMPs (e.g. detention basins, bioretention filters, etc) to meet the TMDL flow targets. The TMDL set forth that watershed hydrology must be controlled in the Bartlett Brook Watershed to reduce high flow discharges and increase base flow in order to restore degraded water quality and achieve compliance with the Vermont Water Quality Standards (VWQS). Components of the FRP, as outlined in the MS4 general permit, include the identification of retrofits to existing BMPs with expired State stormwater permits, new BMP controls, a financial plan, and a regulatory analysis.

Three (3) MS4's including the City South Burlington, Town of Shelburne, and the Vermont Agency of Transportation (VTRANS) own impervious cover within the Bartlett Brook impaired watershed. The contributing MS4s agreed to prepare a joint FRP for the watershed.

2.1 TMDL Flow Targets

In response to Bartlett Brook not meeting the water quality standards set forth in Section 303(d) of the Federal Clean Water Act, the VTDEC developed TMDLs for impaired watersheds using flow as a surrogate for pollutant loading. The basis for the TMDL development was the comparison of modeled Flow Duration Curves (FDCs) between impaired and attainment watersheds. The Program for Predicting Polluting Particles Passage through Pits, Puddles, and Ponds, Urban Catchment Model (P8) was used to model gauged and ungauged watersheds in Vermont and develop Flow Duration Curves (FDCs) from which a normalized high flow and low flow per drainage area in square miles (cfs/sq.mi.) were extracted.

An FDC is a graph that displays the percentage of time during a given period where flow exceeds a certain value. For the purposes of the Bartlett Brook Stormwater TMDL, VTDEC determined that the “low” flow target would be represented by the 95th percentile (Q95%) of the curve and the “high” flow target would be represented by the 5th percentile (Q0.3%). The high and low flow values from the FDCs were then compared between “impaired” watersheds and comparable “attainment” watersheds to determine a percent change (i.e. reduction of high flow, increase of low flow). The percent change was reported in the EPA approved TMDL for each impaired watershed. The high-flow (Q0.3%) was determined to be relatively equivalent to the 1-year design storm flow (2.1 inches of rain over a 24-hour period in Chittenden County). Therefore, stormwater BMPs designed to meet the VTDEC Stormwater Management Manual’s Channel Protection volume (CPv) storage standard were used to address the required high-flow reduction target.

2.1.1 Future Growth Modified Target

The TMDL flow targets and future growth assumptions used by VTDEC in development of TMDL targets were reviewed as part of the FRP development. In February 2014, at the request of the City of South Burlington, the CCRPC completed a study to estimate the additional non-jurisdictional impervious growth expected in the Bartlett Brook over the next 20 years (Appendix 1)³. Non-jurisdictional growth is by definition impervious area that does not require a stormwater permit, and is therefore important to account for within the 20 year management plan.

The study estimated a future growth of 5.7 acres, accounting for the maximum new impervious surfaces allowed by the zoning lot coverage for each available parcel of land within the City. Modified TMDL flow targets were determined by multiplying the portion of the TMDL target associated with future growth (FG) by a correction factor as follows:

³ Chittenden County Regional Planning Commission (CCRPC). 2014. Non Jurisdictional Impervious Surface Analysis for the Bartlett Brook Watershed.

$$\text{Modified Flow Target} = (\text{Target \% with no FG}) + (\text{Target \% from FG}) * \left(\frac{\text{Revised FG acres}}{\text{Original FG acres}} \right)$$

The approved original TMDL flow targets and modified flow targets with a revised future growth for Bartlett Brook are as follows:

Table 1: TMDL flow targets and modified targets with revised future growth

Flow Target	Target High Flow Q 0.3 (± %) Reduction	Target Low Flow* Q 95 (± %) Increase
TMDL Targets (Stormwater allocation only)	-8.80	8.80
TMDL Targets with 50 acres of Non-Jurisdictional Future Growth	-33.20	13.20
TMDL Modified Targets with 5.7 acres of Non-Jurisdictional Future Growth*	-11.60	9.30
* Modified target was calculated as: $-(8.8\%) + (-24.4\%)(5.7 \text{ ac}/50 \text{ ac}) = -11.60\%$ *The low flow target is not actionable under the TMDL, but is included because improving base flow in the watershed is still a water quality goal.		

While the low-flow goal is important to ensure flow during the dry summer months, it is not an actionable requirement in the EPA approved TMDL, and therefore was not the primary focus of the FRP BMP identification for this study.

2.2 MS4 Permit Background and Requirements

An MS4 is a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, or man-made channels) that are designed or used for the collection or conveyance of stormwater discharged to waters of the State or waters of the United States. MS4 systems do not include combined sewer systems that are part of publicly owned wastewater treatment facilities.

On December 5, 2012, Vermont's revised MS4 Permit was issued. This MS4 permit was the second MS4 General Permit issued by the VTDEC. The first MS4 permit was issued in 2003 and amended in 2004. Both the 2004 and 2012 permits authorize stormwater discharges within the urbanized areas of small MS4s. Small MS4s included cities, towns, counties, airports, highway departments, and universities. The City of South Burlington, Town of Shelburne, and Vermont Agency of Transportation were designated as regulated small MS4s, as were Burlington, Colchester, UVM, Essex, Essex Junction, Milton, Williston, Winooski, and Burlington International Airport.

Included in the 2012 MS4 permit issuance were new requirements for municipalities to develop FRPs to implement the stormwater TMDLs. The FRPs must be developed

for each impaired watershed within three (3) years of the date of issuance of the authorization to discharge to the permittee under the general permit, by October 1, 2016, and must include the following elements:

- 1) An identification of the required controls
- 2) A design and construction schedule
- 3) A financial plan
- 4) A regulatory analysis
- 5) The identification of regulatory assistance, and
- 6) Identification of any third party implementation.

The schedule shall provide for implementation of the required BMPs as soon as possible, but no later than 20 years from the effective date of the permit; before December 5, 2032.

3. BMPDSS Model Assessment

In an effort to implement the Vermont Stormwater TMDLs, the VTDEC worked with an external consultant (TetraTech) to develop the computer-based VT BMPDSS, a VT-specific hydrologic BMP assessment model. This modeling tool was developed by TetraTech, Inc., with considerable investment from EPA Region 3 and Prince George's County, Maryland, and was adapted for use in Vermont using funding from the Vermont Agency of Natural Resources (ANR). The purpose of the modeling tool was to predict progress toward the TMDL flow targets based on proposed BMP implementation scenarios to help MS4 communities identify different BMP options and associated costs.

In order to complete a flow target assessment, VTDEC developed three model scenarios for each impaired watershed, including a "Base" (Pre-2002), "Existing" conditions (Post-2002), and an optimized credit scenario (meeting the flow restoration target). The base scenario (Pre-2002 model) included all stormwater BMPs installed prior to issuance of the VT Stormwater Design Standards in 2002. The land use data used in this scenario was derived from 2002 Quickbird satellite imagery. An existing scenario (Post-2002 model) was then developed with all existing BMPs designed to the 2002 VT Stormwater Design Standards, providing credit toward the flow target on a percent change basis compared to the base scenario. The optimized credit run was used by VTDEC to gage the estimated cost and level of effort to reach the flow targets in each impaired watershed. During the optimized credit run, a theoretical full build-out of BMPs were placed in each subwatershed by the model with a goal of minimizing cost and maximizing flow benefit. Results from the BMPDSS model output were provided as unadjusted cubic feet per second (cfs) and normalized flow (flow per drainage area, cfs/sq. mi). The unadjusted flow was used in the determination of progress towards the TMDL targets to eliminate the effect of watershed area in the percent change comparison.

3.1 Existing Condition Review

3.1.1 Permit Review

As per subpart IV.C.1 of the approved MS4 general permit, all expired stormwater permits in the watershed were acquired and reviewed for inclusion within the BMPDSS model assessment. The expired permits were sorted into two groups: Group 1) existing stormwater systems with a CPv BMP which provides extended detention of the 1-year design storm, and Group 2) those without a CPv BMP (e.g. system of storm drains). The Group 1 list was compared to the current BMP list included in the BMPDSS models to check for omissions (Table 2 below). Only expired permit systems that include a BMP with CPv storage were included in the BMPDSS model, because only BMPs with CPv storage provide credit toward meeting the flow targets. Field assessments were then completed at each site with an existing CPv detention structure, to identify if the facility was operating according to the approved expired permit and if there was opportunity for an upgrade to the 2002 Vermont Stormwater Design Standards. Several of the expired permits are now covered under a Residual Designation Authority (RDA) permit from the state, in which the private permittee applied for a renewal of their permit with the State. A full list of the expired permits discharging to the Bartlett Brook and the type of system covered under the permit is included in Appendix 9 (Table A-9).

Table 2: Expired Permits with Stormwater BMPs in the BMPDSS Model

Permit #	Project Name	BMP Type in Model	Permit Status	RDA	Permit Issued
1-1404.9912	Irish Farms Residential Subdivision	Ponds (3)	Issued	n/a	5/31/2000
1-0523.XXXX	Champ Carwash	Pond, Swale system	Issued	6280-9030	11/3/1987
1-1155.9806	Pinnacle at Spear	Ponds (2)	Issued	n/a	4/21/1999
3121-9010	Willie Racine Jeep Isuzu	Ponds (2)	Issued	n/a	11/24/2003
1-1372.9905	Staybridge Suites & Harbor Sunset Hotel	Infiltration Trenches (2)	Issued	6296-9030	9/1/1999
	Oil n' Go	Swale	n/a		4/1/1999
2-0261.XXXX	Overlook at Spear/Summit at Spear	Ponds in series (4)	Issued	n/a	4/17/1985
1-0818	IDX headquarters	Dry Wells	Issued		6/2/2003

*Table Prepared by Emily Schelley (VT DEC 2014). Revised by WCA (2014)

3.1.2 VTDEC BMPDSS Existing Model Review

Verification of the drainage areas and design of the existing BMPs included in the Base (Pre 2002) and Credit (Existing Condition Post 2002) models was completed during

the field assessments. The result of these assessment were compared to the DEC model inputs in order to identify any discrepancies. Updated input files for the Base and Credit models were submitted to VT DEC in order to run the updated models. Input files included revised GIS shapefiles for subwatersheds, BMP locations, BMP drainage areas, as well as HydroCAD (Version 10.0) models used to convey the BMP design parameters. Each BMP design was then converted by State DEC Stormwater Section staff to the equivalent system in the BMPDSS model, which has a slightly different interface for defining the BMP design. Adjustments were made to certain BMP designs, in cases where the design of the BMP in HydroCAD was not directly transferrable to the BMPDSS format.

The **Base (Pre 2002) model** was revised as follows:

Subwatershed Mapping:

- ❖ **Deerfield Street Walking Path:** Subwatershed boundaries were adjusted to account for a channel along the walking path, just off Deerfield St.
- ❖ **Bartlett Brook Central (Pheasant Way):** SW 12 Boundary was corrected to reflect on the ground conditions.
- ❖ **Harbor View Road:** Subwatershed boundaries along Harbor View Rd. were adjusted to reflect roof drainage and more accurate topography data.
- ❖ **Parking Lot Across from Karen Drive:** An existing parking lot and building off Karen Dr. had previously been excluded. The roof drain was confirmed to drain to Bartlett Brook.
- ❖ **Southern watershed Boundary:** The southern boundary was revised to reflect more accurate topography data and field assessment.
- ❖ **Allen Road:** An adjustment to the subwatershed was made to reflect the drainage area of the pond associated with State stormwater permit number 1-1404.
- ❖ **Bartlett Brook Central (Keari Lane):** The subwatershed boundary was corrected to reflect the roof lines and more refined topography data.
- ❖ **Brownell Way:** The subwatershed boundary was revised to better reflect more refined topography data.
- ❖ **Yandow Drive:** The subwatershed boundary from Yandow Dr. to Stonehedge Dr. was corrected to reflect on the ground conditions.

BMP Design Entries:

BMP design entries were revised to reflect field confirmed structures for State of Vermont permitted BMPs including:

- # 1-1404 detention ponds A and B at the Irish Farm Condos along Harbor View Rd.
- #1-1155 detention pond on the Pinnacle at Spear development on Spear St.
- #1-1372 detention pond at the Stay Bridge Suites on Spear St.
- #2-0261 system of 4 on-stream ponds located off Deerfield Dr.
- #1-0818 dry wells and an infiltration tank at the IDX Headquarters along Green Mountain Dr.

The **Post2002 (Credit) model** including all BMPs installed after the 2002 stormwater standards (“Post 2002”) was revised as follows:

Subwatershed Mapping:

- ❖ **RDA Permits:** RDA permits with proposed changes to the existing stormwater system were added to the model by VTDEC staff (Emily Schelley) including #6280-9030 Harbor Heights Condominiums, #6281-9030/#6342-9030 Freedom Nissan, and #6294-9030.1 Bay Court Condominiums. Adjustments to the subwatershed boundaries were made to account for the proposed stormwater system changes.

BMP Design Entries:

- ❖ **6280-9030:** Champ Car Care located on Shelburne Rd. The outlet structure was field confirmed and adjusted.

4. Required Controls Identification

The process of BMP identification involved an initial assessment of the existing BMPs with expired permits that did not already meet the CPv standards in the 2002 Vermont Stormwater Management Manual (VSMM) to determine if they could be retrofit to meet the VSMM design standards (Table 2). Upon review of the existing BMPs, it was determined that additional new BMPs would be required to meet the high-flow and low-flow targets. An initial desktop assessment of the watershed was completed to identify open spaces ideal for BMP implementation. A focus of this effort was to first evaluate property owned by the MS4s where projects could be implemented more readily than on private property. In addition, the location of proposed BMPs across the watershed was taken into consideration to provide storage throughout the watershed. The effort also focused on areas with a high-percentage of impervious coverage where flows were expected

to be highest and where infiltration may be possible, as indicated by mapped Natural Resource Conservation Service Hydrologic Soil Group A⁴ or B⁵ soils.

After an initial list of retrofit sites were identified, a preliminary field assessment was completed at each location to document potential constructability issues and review mapped drainage areas for the proposed BMPs. The BMPs were then modeled using HydroCAD to meet the CPv storage criteria for cold water fish habitat (12-hour detention standard), and incorporated into the BMPDSS model. The initial model iteration, “Credit 1” scenario, was followed by subsequent iterations of the proposed model in which additional proposed BMPs were added to meet the flow targets.

Once the final list of proposed BMPs was determined to meet the flow targets, the projects were ranked using a comprehensive ranking matrix. In addition 30% preliminary engineering designs were developed for the top 4 projects. Orthophoto-based sketch plans for all other projects are provided in Appendix 2.

The top four projects include:

- Bartlett Bay Stormwater Treatment System (BBSTS) Expansion
- Bartlett Brook Central Infiltration Gallery
- Horticulture Farm Basin with Deerfield Dr. Dug Pond
- Irish Farm Condos Pond Retrofit

BMP feasibility was determined based on available space, mapped NRCS soils, existing 1-ft topographic elevation control derived from LIDAR, and mapped stormwater and wastewater infrastructure provided by the City and VTRANS. Supplemental topographical survey data was collected for the top 4 projects as needed. An in-depth engineering assessment will still be required at each site to confirm the presence/absence of utilities, natural resource constraints, and potential transportation impacts as part of the final design process.

4.1 BMPDSS Model Assessment Results

The final BMP scenario was developed based on an iterative assessment using the BMPDSS modeling tool. The initial model run “Credit1” included five (5) BMPs, addressing **139%** of the modified high-flow target, and **0%** of the low-flow target. The existing condition low-flow was **below** the baseline condition (pre 2002). Therefore, while the Credit1 run shows 0% of the low-flow managed, the proposed BMPs actually increased the existing condition low-flow to meet the baseline (pre 2002) condition. Seven (7) additional BMPs were identified and assessed followed by a subsequent model run “Credit2”. Credit2 was estimated to manage **187%** of the modified high-flow target and

⁴ Group A is sand, loamy sand or sandy loam types of soils. It has low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission.

⁵ Group B is silt loam or loam. It has a moderate infiltration rate when thoroughly wetted and consists chiefly or moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.

47% of the low-flow target. Additional GSI collections were added to the final proposed scenario “Credit3_GSI” and found to manage **194%** of the modified high-flow target and **47%** of the low-flow target (Table 3). It should be noted that the groundwater component of the BMPDSS model was found to lack sensitivity based on past experience with the model for other watersheds. The estimated increase in runoff volume infiltrated for the 1-year storm by the proposed BMPs was not reflected in the estimated change in baseflow for the watershed. This general observation has been noted by the State as well as other model users. The model is not sensitive enough to detect the change in baseflow as a result of the addition of smaller GSI projects, and hence zero percent (%) change between the Credit2 and Credit3_GSI runs was observed. A final model run was completed, “Credit3”, to include several additional lower-priority projects, to represent the maximum build-out of retrofit projects. A full modeling summary including all model runs completed under this contract as compared to the original TMDL and modified targets (high and low-flow targets) is included in Appendix 3 (Table A-3-1). A summary table of the proposed BMPs added to each model scenarios is also included in Appendix 3 (Table A-3-2). The table shows the model run to which the BMP was first added. The BMPs were maintained in the model for subsequent “Credit” runs.

Table 3: BMPDSS Model Runs Summary for Proposed FRP Scenario

Model Run	Description	High Flow Reduction (%)	BMPDSS Model Run Date
TMDL Modified Targets with 5.7 acres of Non-Jurisdictional Future Growth		-11.60	----
DEC Existing Condition Model	DEC's existing model, includes all Post2002 BMPs	-1.71	1/31/2014
WCA Revised Existing Condition Model	Model revisions to existing BMPs.	-2.54	12/9/2014
Percent of Modified Target Managed (w/ Existing 12/9/14 model)		22%	----
Credit3 Model with GSI (Proposed FRP Scenario)	Add GSI Practices to Credit2 model scenario	-22.56	12/9/2014
Percent of Modified Target Managed (with Credit3_GSI run)		194%	----

4.1.1 Proposed FRP Scenario BMPDSS Model Results

The final proposed BMP list is represented in the model run “Credit3_GSI” which includes 18 proposed BMPs (Table 4). The final FRP scenario is estimated to provide a -22.56% **reduction** in the high flow ($Q_{0.3\%}$) which is a percent change between the unadjusted flow in the baseline condition and credit scenario (Table 3). This surpasses the required high-flow target of -11.60% from baseline conditions, addressing **194%** of the target with a significant Factor of Safety (FOS). The additional FOS is included in the recommended BMP list to provide the MS4’s additional options, in the event the list has to be modified or as conditions in the watershed change from what is present today.

The individual and cumulative percent of the high-flow target mitigated is also included in Table 4, calculated based on the CPv volume storage and the BMPDSS model run results. The BMPDSS model develops a FDC from which it was determined the High-flow ($Q_{0.3\%}$ cfs) is approximately equivalent to the 1-year storm peak flowrate. The 2002 Vermont Stormwater Management Manual design standard for Channel Protection (CPv) requires mitigation of the 1-year storm event. Therefore, CPv volume storage is used as an indicator of the BMPs contribution toward the estimated high-flow reduction for detention BMPs and increase in baseflow for infiltration BMPs in the BMPDSS model. Essentially, the high-flow is directly reduced in the model by mitigating the CPv volume. The individual and cumulative percent mitigated allows for a quick understanding of the relative benefit of each BMP toward meeting the high-flow target.

Based on the “Cumulative Percent of Target” addressed, the MS4’s would only need to implement the top two projects to meet the high flow target. The table is set up so that in the event one of the top projects is determined infeasible, the projects can be rearranged to determine which projects will then need to be implemented to meet 100% of the high-flow target. The ultimate determination for implementation of projects that provide benefit beyond the high-flow target (> 100%) will be made by the State based on monitoring data or other relevant information (MS4 General Permit Sec. IV.J.3). It is also possible that requirements related to existing expired State stormwater permits will necessitate improvements to some of these systems. The recommended FRP scenario is meeting the full flow restoration target, with a revised future growth of 5.7 acres, through implementation of the recommended stormwater BMPs (Table 4). For additional future growth above 5.7 acres, the City plans to manage this growth with a Low-Impact Development (LID) zoning ordinance, which will require management of new impervious that is not covered under a state stormwater permit.

5. Proposed Implementation Plan

The final proposed BMP implementation plan includes a total of 18 stormwater BMPs including five (5) retrofits to existing BMPs with expired permits, four (4) new detention systems, three (3) new infiltration systems, and six (6) green stormwater infrastructure (GSI) projects. Credit toward the flow target is also provided by nine (9) existing stormwater structures. The proposed BMPs are summarized in Table 4, including the impervious cover treated, drainage area, and CPv volume storage estimated by the HydroCAD design model. A map of the proposed BMP locations is included in Appendix 4.

Table 4: Final Proposed BMPs for the Bartlett Brook FRP

Proposed BMP ID	Owner-ship where BMP is located	BMP Type	Permit #	Runoff Area (ac)	Impervious Cover Managed (ac)	Channel Protection Volume (CPv) Storage		Percent of High-Flow Target Managed	Cumulative Percent of High-Flow Target Managed ²
						CF	Ac-ft		
Existing Post2002 BMPs ¹	Varies	Varies	Varies	--	--	91040	2.09	22%	22%
Bartlett Brook Central	City of S. Burlington	Infiltration Gallery	Expired #1-0202 and 2-0120	84.22	16.11	73616	1.69	46%	68%
Horticulture Farm Basin	UVM	Bioretention	Expired #1-1155	33.79	6.35	66124	1.52	42%	110%
Underwood Stormwater Pond	City of S. Burlington	Detention Basin	Drains to Expired #2-2061	44.29	5.99	36590	0.84	23%	133%
Bartlett Bay Stormwater Treatment System (BBSTS) Expansion	Private Owner	BBSTS Wetland	5625-9010, 2-0180, 2-0153, 1-0734	15.86	9.51	39291	0.55	15%	148%
Laurel Hill Development	UVM	Culvert Retrofit	NP	109.47	21.13	15899	0.37	10%	158%
Holiday Inn Parking Lot	Developer -Pizzagalli	Detention Basin	6297-9030	5.03	3.20	13286	0.31	8.4%	166%
Irish Farm Condos Pond B	HOA	Pond Upgrade	Expired # 1-1404	16.30	3.38	6578	0.15	4.1%	171%
Brownell Way	City ROW	ROW Infiltration	Expired #2-0261	2.58	0.83	5445	0.13	3.4%	174%
Whately Rd	City ROW	ROW Planter	Expired #2-0261	3.32	0.87	5227	0.12	3.3%	177%
Deerfield Dive 1	City ROW	ROW Infiltration	Expired #2-0261	2.31	0.80	5227	0.12	3.3%	181%
Pinnacle at Spear Pond B	Private Owner	Pond Upgrade	Expired #1-1155	3.45	0.22	4704	0.11	3.0%	184%
Deerfield Drive 2	City ROW	ROW Planter	Expired #2-0261	1.61	0.48	4312	0.10	2.7%	186%
Horticulture Farm Detention Pond	UVM	Detention	Expired #1-1155	7.66	1.13	3920	0.09	2.5%	189%
Allen Road	City ROW	Detention Basin	NP	6.38	1.44	3136	0.07	2.0%	191%
Windsor Court	City ROW	ROW Infiltration	Expired #2-0261	1.05	0.31	2483	0.06	1.6%	192%

1690 Shelburne Road	VTRANS/ Developer - Pizzagalli	Detention Basin	5625-9010	0.80	0.63	1873	0.04	1.2%	193%
Pinnacle at Spear Pond A	Private Owner	Pond Upgrade	Expired #1-1155	10.25	3.30	1263	0.029	0.8%	194%
Brownell Way-3	City ROW	ROW Planter	Expired #2-0261	0.96	0.08	610	0.01	0.4%	194%
TOTAL:				75.75			6.30		

Notes:

1- Existing Post 2002 BMPs provide credit toward the TMDL flow target. Here the existing Post 2002 BMPs are lumped to show the total benefit of existing BMPs.

2- Cumulative percent of the high-flow target managed is calculated based on the CPv storage and the BMPDSS Model results from the "Credit3_GSI" and Existing Condition (12/9/14) runs. As each BMP is added the total % managed increases.

5.1 Proposed BMPs

Bartlett Bay Stormwater Treatment System (BBSTS) Expansion

The existing Bartlett Bay Stormwater Treatment System was designed in 2002 to provide WQ treatment for runoff from a portion of Route 7 as well as several buildings along Green Mountain Dr. A 15" pipe was installed with the original system to plan for future connections from Route 7. The proposed expansion of this system would route approximately 15.86 acres of additional area from a portion of Route 7 and Harborview Road to the BBSTS system via a new stormline connection on Route 7 (Figure 1). The expansion would involve implementing a new forebay for the additional connection in front of the Oil N Go property, as well as expanding the southeast portion of the wetland. The existing access road would also be repositioned.





Figure 1: Proposed location for new connection to BBSTS from Route 7.

Bartlett Brook Central Infiltration Gallery

The proposed Bartlett Brook Central (BBC) infiltration gallery would manage runoff from 84 acres at the confluence of two existing outfalls, both of which have significant erosion issues (Figure 2). There is a larger open area, with soils mapped as Hydrologic Group “B”, providing an opportunity for infiltration. The infiltration gallery would require 330 StormTech SC-740 recharge chambers, with a Downstream Defender at the confluence of the two outfall connections. The system was designed as an offline practice to mitigate just the 1-year storm volume (CPv), estimated to be 0.59 ac-ft, through the use of several flow-splitters.



Figure 2: North outfall shows evidence of significantly erosion.

A majority benefit of this project is the fact that it is on City of South Burlington property and makes use of a previously unused space, without changing the overall appearance of the area for residents. Land acquisition is not required for the project which significantly reduces the cost as well.

Horticulture Farm Bioretention (Option 1) and Detention Pond (Option 2)

The Overlook Drive walking path currently has two culverts which are directed to a swale along the path that carries significant flows downstream (Figure 3). Additionally, the mapped soil in this area is hydrologic group “B” providing opportunity for infiltration. The proposed site was identified as an excellent candidate to improve the overall aesthetics of the walking path, while also providing significant stormwater management. The project would involve a retrofit of the swale into a 0.81 ac-ft bioretention basin. A berm in the center of the basin would provide an extended flow path to improve water quality treatment.



Figure 3: Overlook Dr. Walking Path

The BMP is located on the UVM Horticulture Farm property, for which irrigation is an ever-present need. An existing pond just downstream of the proposed basin was identified as a candidate site “Horticulture Detention Pond”. The 10-year storm (Qp10) overflow from the Horticulture Farm basin would be routed to the dug pond, providing a store of usable water on-site and Qp10 control for the basin.

Underwood Stormwater Pond

The confluence of the existing stormline along Spear St., just South of Nowland Farm Rd. has been the source of flooding during large storm-events. The proposed project would involve a retrofit of the existing roadside swale into a detention basin (Figure 4), designed to provide detention of the 1 year storm event for a 44.3 acre area in the upper Bartlett Brook watershed. This project is currently in the preliminary design phase under a contract between Stantec and the City of Burlington. The proposed retrofit included in the FRP analysis is a conceptual-level design for a detention basin.



Figure 4: Spear St. roadside swale.

Laurel Hill Development Culvert Retrofit

An existing 32" culvert, located on the UVM horticulture farm property, just South of the Laurel Hill Neighborhood was identified as an opportunity for retrofit to provide more storage. The proposed retrofit would involve installing a headwall at the culvert and outlet control structure to increase the CPv storage capacity, while still safely passing the larger storm events. There may be issues with alteration of an on-stream structure, as DEC has placed limitations on new on-stream structures.

Holiday Inn Parking Lot BMP

The Holiday Inn, located off Shelburne Rd, parking lot is currently covered under an RDA permit (6297-9030). However, the system does not provide any flow-control, only water quality treatment in a sedimentation tank. There is the potential to implement an underground infiltration gallery in the open space near the Holiday Inn Parking lot (Figure 5). There is also potential to route drainage from the Staybridge Hotel, which is currently routed to a detention pond that does not meet the VT CPv standard.



Figure 5: Site proposed for Holiday Inn BMP

A conceptual off-line underground infiltration basin, sized to mitigate the 1-year storm was included in the FRP analysis. Further verification of the new connections for the system will need to be completed to determine project feasibility. An alternative option would involve a retrofit of several green strips within the parking lot with dry wells and infiltration swales. The green belts provide an opportunity for a distributed green stormwater management collection system for the parking lot runoff.

Allen Road Detention Basin

The Allen Road Detention Basin was designed as a retrofit of an existing ROW swale. The basin would mitigate runoff from a 6.38 acre drainage area, providing 0.07 ac-ft of storage. The site would require a new culvert under the roadway in order to route additional runoff to the swale.

1690 Shelburne Road

An existing outfall from Shelburne Road, parallel to the Oil N Go property, was identified as a retrofit candidate site. An underground detention chamber is proposed to detain the 1-year storm volume (CPv) from the existing Route 7 stormline, via a flow splitter. The existing outfall pipe would need to be reset to make room for the chamber. The detention chamber may encroach on the flood plain for the Bartlett Brook culvert, and could also have other utility conflicts limiting the space available for the proposed system.

5.2 Expired Permit Proposed Retrofits

Overlook Drive Neighborhood (#2-0261) GSI Collection System

Currently, the neighborhood South of Deerfield Dr./Spear St is covered under an expired permit #2-0261. The site was built with four on-stream detention ponds all of which do not function according to the permit. Retrofit of these ponds is the preferred alternative for improving stormwater management. However, this may be challenging given the State's limitations for on-stream alterations. Due to lack of available open space at the end of the catch basin system, a more distributed management system is also possible. The Overlook Drive neighborhood was selected as a GSI build-out candidate area, in which opportunities for ROW planters were identified. The area has a range of soil types, some of which are Hydrologic Group "A" and "B", providing opportunity for infiltration. Candidate sites were identified in which a filter practice could be installed in the ROW and tied into the existing storm water collection system (Figure 6). Potential conflicts with trees and utilities may exist.



Figure 6: Candidate Site for detention filter in ROW along Brownell Way.

Irish Farm Condos Pond B and C (#1-1404b) Retrofit

The existing Irish Farm Condos stormwater system is currently under expired permit #1-1404. The system consists of two interconnected detention ponds. The proposed retrofit would involve converting the existing upper pond (Pond C) to an expanded gravel wetland system, while maintaining some of the native tree growth. Pond C would be designed to mitigate the 10 year storm from an additional 5.4 acres, tied into the proposed gravel wetland system via a new 18" culvert and catch basin "flow splitter". The lowest pond would also be retrofit to provide detention of the 1 year storm event. The system is on private property, owned by the condos HOA.



Pinnacle at Spear Pond B (#1-1155a and b)

The existing ponds covered under State permit #1-1155 for the Pinnacle at Spear development were assessed for retrofit. The outlet structure on Pond a (North lot) is proposed for retrofit. This would include replacing the existing 12" culvert with a 3" low-flow orifice. The outlet structure on Pond b (along Spear St) is also proposed for retrofit. This would include the addition of two low-flow orifices, 1" at 371' and a 2" at 373.5'. The retrofits will provide 0.139 ac-ft of CPv storage.



Figure 7: #1-1155 Pond a



Figure 8: #1-1155 Pond b

5.3 Watershed-Wide Project Ranking

All proposed BMPs identified as part of FRP development in the five stormwater impaired watersheds of Potash, Bartlett, Englesby, Centennial, and Munroe Brook were ranked and a project prioritization was created. Considerations that factored into the ranking of BMP projects include the estimated benefit of a BMP towards the FRP's flow restoration targets, and the amount of impervious area treated. The comprehensive ranking matrix ranked the proposed BMP projects based on the following criteria, which were grouped into four general categories as shown in Table 5.

Table 5: Project Ranking Matrix

Category	ID	Criteria
Cost/Operations	A	Project Cost per Impervious Acre
Project Design Metrics	B	Impervious Acres Managed (ac)
	C	Channel Protection Volume (CPv) Mitigated, (ie. 1-year Storm)
	D	Volume Infiltrated (ac-ft)
Project Implementation	E	Permits
	F	Land Availability
Other Project Benefits/Constraints	G	Flood Mitigation (Is existing flooding issue mitigated by project?)
	H	TMDL Flow Target Addressed (Q03, Q95)
	I	Lake Champlain Phosphorus TMDL
	J	Other Project Benefits/Constraints

Values for each criteria were identified and assigned a relative score, so that proposed BMP projects could be ranked based on a total score. The final ranking of proposed projects is included in Table 6 below. The scoring key and full descriptions of the criteria are included in Appendix 5.

Table 6: Ranked Proposed FRP BMPs based on comprehensive ranking matrix

ID #	Site ID	BMP Type	Retrofit Description	Total Score
BB0003	Bartlett Brook Central (BBC)	Infiltration Gallery	Underground infiltration gallery at confluence of two large outfalls.	25.75
BB0010	Horticulture Farm Bioretention	Bioretention	Bioretention basin along walking path.	19.75
BB0016	Underwood Stormwater Pond	Detention Basin	Detention BMP in ROW and/or on City property. Would alleviate flooding downstream.	19.5
BB0009	Holiday Inn Parking Lot	Detention Basin	Detention BMP on private open land. Planned for design as part of 1690 Shelburne Rd. Project. Infiltration potential	18
BB0004	BBSTS Expansion	Wetland	Route CPv storm to BBSTS Wetland, and add forebay.	16.75
BB0014	Pinnacle at Spear Pond A	Pond Upgrade	Drains to proposed Hort Farm Basin. Retrofit riser and deepen.	16.75
BB00012	Irish Farm Condos Pond B	Pond Upgrade	Upgrade existing pond to gravel wetland STP, with more storage. Route additional 5.47 acres to Pond B.	16
BB0007	Deerfield Drive 1	ROW Infiltration Trench	System of Infiltration Trenches in ROW.	16
BB0017	Whatley Rd 1-5	ROW Planter	System of Filter strips with storage in ROW.	16
BB0002	Allen Road	Detention Basin	Detention Basin in ROW. Requires new culvert under roadway.	15.5
BB0013	Laurel Hill Detention Pond at Horticulture Farm	Culvert Retrofit	Block existing culvert and add storage.	15.5
BB0005	Brownell Way	ROW Infiltration Trench	System of Infiltration Trenches in ROW.	15
BB0018	Windsor Ct-1	ROW Infiltration Trench	System of Infiltration Trenches in ROW.	15
BB0015	Pinnacle at Spear Pond B	Pond Upgrade	Drains to proposed Hort Farm Basin. Retrofit riser and deepen.	13.75
BB0011	Horticulture Farm Detention Pond	Detention	Provide irrigation pond for UVM farm	12
BB0008	Deerfield Drive 2	ROW Planter	System of Filter strips with storage in ROW.	13
BB0001	1690 Shelburne Rd.	Detention Basin	Detain unmanaged portion of Route 7 in underground detention chamber.	12
BB0011	Horticulture Farm Detention Pond	Detention	Provide irrigation pond for UVM farm	12
BB0006	Brownell Way-3	ROW Planter	System of Filter strips with storage in ROW.	10

6. Design and Construction Schedule

A Design and Construction (D&C) schedule is a required element of the final approved FRP. This schedule must show how the proposed BMPs included in the FRP can be implemented over a timeframe of less than 20 years from the date of MS4 permit issuance. This means that all BMPs associated with FRPs must be implemented prior to December 5, 2032. The City of South Burlington has impervious ownership in five impaired watersheds; Bartlett, Englesby, Centennial, Monroe, and Potash Brook. Therefore, all five impaired watersheds were considered when developing a realistic D&C schedule for the City. However, only the projects located within the Bartlett Brook watershed are presented in the D&C schedule in Appendix 6.

In addition to a project's score within the BMP ranking matrix, development of a BMP implementation schedule required the consideration of additional factors. A number of the proposed BMPs are currently covered by expired State of Vermont stormwater permits. These BMPs were included in the beginning of the schedule so that the associated properties could complete the required stormwater improvements and achieve permit compliance. Other BMPs involve property containing more than 3 acres of impervious area. VTDEC is currently drafting a "3 Acre Stormwater Permit" that would require stormwater retrofits at these sites. BMPs in this situation were also placed towards the front of the implementation schedule. In addition, some of the proposed BMPs are located on land owned or controlled by the MS4 entities. These BMPs were given priority over those that were located on private property.

The BMP schedule presented in this FRP is expected to receive updates on an annual basis. Projects will be added, modified, or removed as necessary to meet FRP flow targets and respond to actual conditions. The primary reason being that the BMPs presented in the implementation schedule have only been developed to in concept. It is reasonable to anticipate that changes will occur when these concepts are further developed. Depending on actual circumstances, the level of treatment achieved may be more or less than the level of treatment anticipated (e.g. variations in soil conditions allow for either more or less infiltration of stormwater runoff than originally anticipated). These type of modifications are common when advancing BMP plans from concept to final design. Therefore, flexibility in the schedule is necessary to accommodate these changes.

Additionally, in order for project implementation to move forward in a cost effective manner, the MS4s will need to take advantage of opportunities for stormwater improvements as they present themselves. For example, a private property owner may decide to redevelop their property on a schedule that was not anticipated in the current BMP implementation schedule. If this occurs, the MS4s may need to shift available resources from a scheduled project in order to take advantage of a cost savings opportunity.

Finally, projects may need to be shifted in the BMP schedule based on Vermont's changing regulatory system. VTDEC is currently developing an implementation plan for the Lake Champlain Phosphorous TMDL. When this document is finalized, the MS4 permit will require regulated entities to develop Phosphorus Control Plans (PCPs), similar in size and scope to the FRPs being

developed as part of stormwater TMDLs. When this occurs, the FRPs will likely need to be revised based on PCP requirements, which are yet to be defined by VTDEC.

7. Financial Plan

Subject to the requirements of the MS4 permit, a financial plan is required as part of the FRP. This plan must provide initial BMP cost estimates and demonstrate the means by which BMP implementation will be financed. The financial plan must also include the steps that each MS4 will take to implement the finance plan. Initial BMP cost estimates were arrived at using 2014 cost estimates. Once projects were scheduled over the remaining 20 year implementation schedule (17 years remaining), an annual 3% inflation rate based on the construction cost index was applied. Appendix 6 presents inflation adjusted project costs for each BMP project. Applying this inflation rate provides a more accurate annual cost for BMP construction in the later years of the schedule.

7.1 City of South Burlington Financial Plan

In 2005, the City of South Burlington created Vermont's first stormwater utility. Under the stormwater utility system, all developed properties in the City pay an impervious area-based stormwater fee using an Equivalent Residential Unit (ERU) system. These stormwater fees provide the City with a stable funding source that is used to comply with State and Federal stormwater regulations and maintain stormwater infrastructure throughout the City. The stormwater utility was created with the understanding that there would be future stormwater costs related to the five stormwater impaired watersheds located in South Burlington, as well as costs related to future implementation of projects required by the Lake Champlain Phosphorous TMDL. The City anticipates using funds generated from stormwater utility fees to fund a portion of FRP related costs.

Once the BMP cost and implementation schedule was developed, the City of South Burlington Stormwater Utility was able to incorporate this information into its existing stormwater rate model. The City evaluated three different scenarios for funding the BMPs included in the FRP. The first scenario assumed that there would be no grant funding or low interest loans available to assist with implementation. The second scenario assumed that there would be no grant funding available, but low interest loans would be available to help the City pay for implementation. This scenario included \$5M in low interest loans to help pay for BMP implementation. The third funding scenario assumed no loans and that grant funding of approximately \$250,000 per year would be available in 2018 through 2029, and that this amount would increase to \$500,000 in 2030, 2031, and 2032. The impact that these scenarios would have on stormwater utility rates is summarized in Table 7. The resulting annual cost to a single family residential property and commercial property owner containing 1 acre of impervious area is summarized in Table 8. Calculations for "Commercial Property Containing 1 Acre Impervious Area" in Table 8 assume an Equivalent Residential Unit (ERU) rate of 17 and do not take into account the City's relative tier factors, based percent impervious cover, which would yield an ERU range of 13 to 22 ERUs.

Table 7: Stormwater Billing Rate (Cost per Equivalent Residential Unit) Under Different Flow Restoration Plan Funding Scenarios

Fiscal Year	Funding Scenario 1 Receive No Grants and No Loans	Funding Scenario 2 Receive Low Interest Loans, No Grants	Funding Scenario 3 Receive \$250,000 in Grants Annually
2018	\$6.69	\$6.69	\$6.69
2019	\$6.87	\$6.84	\$6.84
2020	\$7.05	\$6.99	\$6.99
2021	\$7.26	\$7.14	\$7.14
2022	\$7.50	\$7.29	\$7.29
2023	\$7.77	\$7.47	\$7.44
2024	\$8.07	\$7.68	\$7.59
2025	\$8.40	\$7.92	\$7.74
2026	\$8.76	\$8.19	\$7.89
2027	\$9.15	\$8.49	\$8.04
2028	\$9.57	\$8.82	\$8.19
2029	\$9.99	\$9.18	\$8.34
2030	\$10.41	\$9.57	\$8.49
2031	\$10.83	\$9.99	\$8.64
2032	\$11.25	\$10.44	\$8.79

Table 8: Annual Stormwater Fee Paid by Property Owners Under Different Flow Restoration Plan Funding Scenarios

Fiscal Year	Funding Scenario 1 - Receive No Grants and No Loans		Funding Scenario 2 - Receive Low Interest Loans, No Grants		Funding Scenario 3 - Receive \$250,000 in Grants Annually	
	Single Family Residential Property	Commercial Property Containing 1 Acre Impervious Area	Single Family Residential Property	Commercial Property Containing 1 Acre Impervious Area	Single Family Residential Property	Commercial Property Containing 1 Acre Impervious Area
2018	\$80.28	\$1,364.76	\$80.28	\$1,364.76	\$80.28	\$1,364.76
2019	\$82.44	\$1,401.48	\$82.08	\$1,395.36	\$82.08	\$1,395.36
2020	\$84.60	\$1,438.20	\$83.88	\$1,425.96	\$83.88	\$1,425.96
2021	\$87.12	\$1,481.04	\$85.68	\$1,456.56	\$85.68	\$1,456.56
2022	\$90.00	\$1,530.00	\$87.48	\$1,487.16	\$87.48	\$1,487.16
2023	\$93.24	\$1,585.08	\$89.64	\$1,523.88	\$89.28	\$1,517.76
2024	\$96.84	\$1,646.28	\$92.16	\$1,566.72	\$91.08	\$1,548.36
2025	\$100.80	\$1,713.60	\$95.04	\$1,615.68	\$92.88	\$1,578.96
2026	\$105.12	\$1,787.04	\$98.28	\$1,670.76	\$94.68	\$1,609.56
2027	\$109.80	\$1,866.60	\$101.88	\$1,731.96	\$96.48	\$1,640.16
2028	\$114.84	\$1,952.28	\$105.84	\$1,799.28	\$98.28	\$1,670.76
2029	\$119.88	\$2,037.96	\$110.16	\$1,872.72	\$100.08	\$1,701.36
2030	\$124.92	\$2,123.64	\$114.84	\$1,952.28	\$101.88	\$1,731.96
2031	\$129.96	\$2,209.32	\$119.88	\$2,037.96	\$103.68	\$1,762.56
2032	\$135.00	\$2,295.00	\$125.28	\$2,129.76	\$105.48	\$1,793.16

It is the City's expectation that significant funding from the State of Vermont and other Federal sources will be available to help with the cost of stormwater TMDL implementation. The State of Vermont has already taken initial steps towards providing this funding. In 2015 the Vermont legislature created the Clean Water Fund (CWF). The CWF was provided with \$2,005,000 in 2016, and \$7,688,000 in 2016. While these initial investments are not at the level necessary to provide significant funding to the MS4 communities subject to stormwater TMDLs, it is our understanding that the State is working to provide additional funding to the CWF in the future. In December 2016, the State Treasurer and State agencies will be delivering a report to the Vermont legislature that provides options for raising significant money to fund the CWF. The City of South Burlington intends to work closely with our legislative representatives to ensure that this funding is made available for the stormwater improvements included in the FRPs. The City of South Burlington will also pursue funding from existing and new grant sources from other organizations including, but not limited to, VTDEC, the Vermont Agency of Transportation, and the Lake Champlain Basin Program.

7.2 Vermont Agency of Transportation Financial Plan

Planning level costs were independently estimated for each VTrans project using a consistent spreadsheet-based method for all projects. As such, some cost estimates may differ slightly from those presented in other FRP documents. VTrans will request state and federal funding for the appropriate amount to implement the BMPs as outlined in their design and construction schedule. For those projects that will require a joint effort with another municipality, VTrans will request funding for their portion of the cost share. In watersheds where VTrans is either not meeting or exceeding their allocated target there may be cost sharing between MS4s.

7.3 BMP Cost Estimates:

Itemized cost estimates were developed for the top 4 priority projects based on 30% preliminary engineering plans. For all other projects, a modified spreadsheet method was used.

7.3.1 Itemized Cost Estimates:

The itemized cost estimates for the top 4 projects are included in Appendix 7. The cost estimates are based on the following criteria:

- **Construction Cost:** The construction costs were developed based on using both VTRANS 5 year average costs, VTRANS Estimator Program, and RS Means (where applicable) and vendor estimates as necessary for each of the itemized units.
- **Construction Contingency:** The construction contingency is calculated as 15% of the construction cost.

- **Final Design Engineering:** The final design engineering cost is estimated based on the State Fee Curve Allowance as developed by VT DEC. The equations used are as follows:
 - for construction costs less than 780,000, construction cost = $\$1,950 + (\text{Construction cost} * 0.069)$
 - for construction costs greater than 780,000, construction cost = $(\text{Construction cost}^{0.9206}) * 0.6788 * 0.30$.
- **Construction Engineering:** The construction engineering cost is based on the State Fee Curve Allowance as developed by VT DEC. The equations used are as follows:
 - for construction costs less than 780,000, construction cost = $\$3,575 + (\text{Construction cost} * 0.1265)$
 - for construction costs greater than 780,000, construction cost = $(\text{Construction cost}^{0.9206}) * 0.6788 * 0.55$.
- **Other costs:** These costs are established based on simple percentages of the construction cost for the project as follows:
 - Administrative = 0.5%
 - Easement Assistance = 1.5%
 - Land Acquisition = \$120,000 per acre (*Value estimated by City Assessor)
 - Legal = 5%
 - Bond Vote Assistance = 0.5%

7.3.2 Cost Estimates Using Spreadsheet Method:

A modified spreadsheet method was used to develop planning level costs for the remaining BMP projects. Horsley Witten (HW) previously completed the Centennial Brook FRP and developed cost estimates using a spreadsheet method⁶ (Memorandum Provided in Appendix 8). Use of the HW spreadsheet method was originally planned. However after comparing the spreadsheet results for the top four projects with the itemized cost estimates, it appeared that modifications would improve the confidence in the spreadsheet estimates. Therefore, revisions to the HW estimates were necessary in order to be consistent with our modifications. These modifications were simple and accomplished using the available data. The following criteria and modifications were applied in the cost estimates as follows:

Design Control Volume (*Modified*): HW based the design control volume on the runoff volume from the managed site from the 1-year storm for offline CPv BMPs, and the 100-year storm + 2 ft freeboard for large aboveground basins. We found the runoff volume overestimated the cost significantly and found the storage-volume to be a preferred metric for the control volume. The storage-volume associated with the

⁶ Horsley Witten Group, Inc. 2014. Centennial Brook Watershed: Flow Restoration VTBMPDSS Modeling Analysis and BMP Supporting Information. Memorandum Dated January 9th, 2014.

1-year storm was used for off-line CPv BMPs only designed to mitigate the 1-year storm, and the 100-year storm + 2 ft of freeboard for large basins.

Unit Costs and Site Adjustment Factors: We used the values developed by HW as summarized in Table 9 below:

Table 9: Retrofit unit costs and adjustment factors

BMP	Base Cost (\$/ft3)
Detention Basin	\$2
Infiltration Basin	\$4
Underground Chamber (infiltration or detention)	\$12
Bioretention	\$10
Green Infrastructure/ Underground Chamber Combo	\$22
Site Type	Cost Multiplier
Existing BMP retrofit	0.25
New BMP in undeveloped area	1
New BMP in partially developed area	1.5
New BMP in developed area	2
Adjustment factor for large aboveground basin projects	0.5

*Excerpt from Horsley Witten Memorandum Dated January 9th 2014 (Page 11)

Site Specific Costs: Not included in the cost estimates at this time.

Base Construction Cost: Calculated as the product of the design control volume, the unit cost, and the site adjustment factor.

Permits and Engineering Costs: Either a 20% (for largest storage volume projects) and 35% for smaller or complex projects.

Land Acquisition Costs (*Modified*): A variation from the HW method was applied. Based on an estimate from the City Assessor, the land acquisition cost was calculated as \$120,000 per acre required for the BMP, applied to projects on private land.

Total Project Cost: Calculated as the sum of the base construction cost, permitting and engineering costs, and land acquisition costs.

Cost per Impervious Acre: Calculated as the construction costs plus the permitting and engineering costs divided by the impervious acres managed by the BMP.

Operation and Maintenance: The annual O&M was calculated as 3% of the base construction costs, with a maximum of \$10,000.

A summary of the cost estimates is included in Table 10 below.

Table 10: Proposed BMPs Cost Estimates

BMP ID	Control	Imp acres	Design Control Volume		Base Unit Cost (\$/cft)	Site Adjust ment Factor	Base Construction Cost	Permits & Engineering Contingency	Land Cost	Total Project Cost	Cost/Imp Acre	Annual O&M
			(cft)	(ac-ft)								
BBSTS Combined	CPv only	9.33	0.55	30% Itemized Cost Estimate						\$ 378,260	\$ 40,534	\$ 8,100
Bartlett Brook Central	CPv only	16.11	1.69	30% Itemized Cost Estimate						\$ 853,730	\$ 52,990	\$ 10,000
Horticulture Farm Bioretention (Option 1)	100-yr	6.35	3.96	30% Itemized Cost Estimate						\$ 267,820	\$ 42,182	\$ 5,700
Horticulture Farm Detention Pond (Option 2)	100-yr	1.13	0.39	30% Itemized Cost Estimate						\$ 184,990	\$ 163,287	\$ 3,900
Irish Farm Condos Pond B	100-yr	3.38	1.06	30% Itemized Cost Estimate						\$ 247,380	\$ 73,198	\$ 3,300
Underwood Stormwater Pond	CPv only	5.99	0.84	36721	\$2	1.5	\$110,163	\$ 22,033	\$90,000	\$ 222,196	\$ 22,060	\$ 3,305
Laurel Hill Development	100-yr	21.13	3.20	139566	\$2	0.5	\$139,566	\$ 27,913		\$ 167,479	\$ 7,927	\$ 4,187
Holiday Inn Parking Lot	CPv only	3.20	0.12	5314	\$12	2	\$127,544	\$ 25,509	\$36,000	\$ 189,052	\$ 47,856	\$ 3,826
Allen Road	100-yr	1.44	0.44	19166	\$2	1.5	\$57,499	\$ 11,500		\$ 68,999	\$ 48,075	\$ 1,725
1690 Shelburne Road	CPv only	0.63	0.12	5227	\$12	2	\$125,453	\$ 43,908	\$30,000	\$ 199,361	\$ 268,401	\$ 3,764

BMP ID	Control	Imp acres	Design Control Volume	Base Unit Cost (\$/cft)	Site Adjustment Factor	Base Construction Cost	Permits & Engineering Contingency	Land Cost	Total Project Cost	Cost/Imp Acre	Annual O&M	BMP ID
Windsor Ct	CPv only	0.31	0.02	1002	\$10	2	\$20,038	\$ 7,013		\$ 27,051	\$ 86,748	\$ 601
Brownell Way-3	CPv only	0.08	0.02	915	\$10	2	\$18,295	\$ 6,403		\$ 24,699	\$ 325,063	\$ 549
Brownell Way	CPv only	0.83	0.08	3354	\$10	2	\$67,082	\$ 23,479		\$ 90,561	\$ 109,256	\$ 2,012
Deerfield Drive 1	CPv only	0.80	0.12	5227	\$10	2	\$104,544	\$ 36,590		\$ 141,134	\$ 177,069	\$ 3,136
Deerfield Drive 2	CPv only	0.48	0.10	4312	\$10	2	\$86,249	\$ 30,187		\$ 116,436	\$ 241,057	\$ 2,587
Whatley Rd	CPv only	0.87	0.16	6752	\$10	2	\$135,036	\$ 47,263		\$ 182,299	\$ 210,490	\$ 4,051
Pinnacle at Spear Pond A	100-yr	3.30	0.686	29882	\$2	0.25	\$14,941	\$ 5,229		\$ 20,170	\$ 6,116	\$ 448
Pinnacle at Spear Pond B	100-yr	0.22	0.461	20081	\$2	0.5	\$20,081	\$ 7,028		\$ 27,110	\$ 122,554	\$ 602
		75.6						Total Cost:		\$3,408,728		

8. Regulatory Analysis

In accordance with the MS4 permit, an FRP requires a regulatory analysis that identifies and describes what, if any additional regulatory authorities, including authority to require low impact development BMPs, that the permittees will need in order to effectively implement the FRP.

Currently, stormwater runoff within the Bartlett Brook watershed is regulated primarily by the VTDEC, City of South Burlington, Town of Shelburne, and VTrans. VTDEC regulates new developments through issuance of Stormwater Discharge Permits with technical requirements as outlined in the 2002 Vermont Stormwater Manual. The City of South Burlington and Town of Shelburne require improved stormwater practices and low impact development for new developments through their stormwater ordinances and Land Development Regulations (LDRs). VTrans regulates stormwater discharges to the state Right of Way through 19 V.S.A. §1111 “Permitted use of the right-of-way”.

The City of South Burlington updated stormwater requirements in its LDRs in June 2016.⁷ The revised LDRs require that any project resulting in ½ acre or more of impervious area implement stormwater controls that prioritize infiltration. The revised LDRs also contain new requirements for properties that are being redeveloped. It is the City’s expectation that these changes will result in gradual improvements in stormwater management over the course of the BMP implementation schedule.

The City of South Burlington also revised its “Ordinance Regulating the Use of Public and Private Sanitary Sewerage and Stormwater Systems” in October 2015.⁸ The ordinance provides a policy regarding the handling of expired VTDEC stormwater permits located in South Burlington. The City will continue to take over responsibility for exclusively residential stormwater systems that complete upgrades. In addition, the revised ordinance allows commercial properties with expired permits to obtain coverage under the City’s MS4 permit if upgrades to the stormwater system are completed. These properties will still be responsible for maintaining their systems, but the permit coverage required by the State of Vermont can now be provided through the City’s MS4 permit instead of obtaining coverage under one of VTDEC’s other permit programs.

While the City of South Burlington has taken significant steps to alleviate the problems caused by expired State of Vermont stormwater permits within its boundaries, there is still a significant

⁷ Section 12.03 – Stormwater Management Standards, “South Burlington Land Development Regulations,” dated 6/27/16, can be viewed at the following link: http://www.sburl.com/vertical/Sites/%7BD1A8A14E-F9A2-40BE-A701-417111F9426B%7D/uploads/LDRs_Effective_6-27-2016_Complete_reduced_size.pdf

⁸ South Burlington’s “Ordinance Regulating the Use of Public and Private Sanitary Sewerage and Stormwater Systems,” dated 10/5/15, can be viewed at the following link: http://www.sburl.com/vertical/sites/%7BD1A8A14E-F9A2-40BE-A701-417111F9426B%7D/uploads/Sewer_and_Stormwater_Ordinance_Final_Clean_10.5.15.pdf

role that the VTDEC needs to play in order to support these efforts. The City's revised ordinance provides the opportunity for properties to obtain their required State of Vermont stormwater permit coverage through the City's MS4 permit, but it does not require it. It is anticipated that some property owners will want to work directly with VTDEC to obtain this permit coverage. In order for South Burlington to effectively implement its FRP, VTDEC needs to update its State permit programs so that properties with expired stormwater permits in stormwater impaired watersheds can obtain permit coverage directly from VTDEC. This updated permit program should require stormwater treatment on the properties that are, at minimum, equal to the stormwater treatment requirements included in the City's LDRs and referenced in the City's Stormwater Ordinance. If VTDEC fails to take this step and creates a permit program that allows properties to obtain permits with minimal stormwater improvements, it has the strong potential to undermine the City's efforts to meet the FRP targets.

A full list of the expired State of Vermont permits with discharges to Bartlett Brook indicating the retrofits proposed under this FRP is included in Appendix 9 (Table A-9).

9. FRP Implementation

The Bartlett Brook FRP was completed to meet the requirements under Part III of the MS4 general permit for the contributing MS4's—City of South Burlington, VTRANS and the Town of Shelburne. According to Subpart IV.C.1. of the General Permit, the MS4 is required to submit a final FRP within 3 years of the permit issuance. The FRP will become a part of the permittees SWMP upon approval.

10. Appendices

Appendix 1: Future Growth Memorandum

Appendix 2: 30% Engineering Plans for the Top 4 Projects in Bartlett Brook & Orthophoto-based Sketch Plans

Appendix 3: Table A-3-1: BMPDSS Modeling Summary and A-3-2: BMP Table

Appendix 4: Map of Best Management Practices Included in the Bartlett Brook Flow Restoration Plan

Appendix 5: Table A-5-1: BMP Ranking Criteria Key, Table A-5-2: Scoring Key

Appendix 6: Bartlett Brook Watershed BMP Design and Construction Schedule

Appendix 7: Itemized Cost Estimates

Appendix 8: Horsley Witten Group Memorandum Dated January 9th, 2014.

Appendix 9: Bartlett Brook Expired Permit List

APPENDIX 1

FUTURE GROWTH MEMORANDUM



Date: April 2, 2014

To: Thomas J. DiPietro Jr., Deputy Director, City of South Burlington

From: Melanie Needle, Senior Planner, CCRPC

RE: Non Jurisdictional Impervious Surface Analysis for the Bartlett Brook Watershed

This memo documents the process used to estimate the additional non-jurisdictional impervious area that will be created in the in the Bartlett Brook Watershed over the next 20 years. The Vermont Department of Environmental Conservation (DEC) created a stormwater TMDL for the Bartlett Brook watershed. In this TMDL, non-Jurisdictional growth is defined as impervious surface growth in the watershed that is not subject to a State stormwater permit. Below is a description of the procedures developed by the Chittenden County Regional Planning Commission (CCRPC) and City of South Burlington to estimate the likely amount of non-jurisdictional impervious area growth that will occur in the watershed over the next 20 years.

Procedure

The analysis was performed in ArcGIS and Excel using the following procedure.

1. Define the study area and quantify the impervious surface for two time periods
 - a. Identify parcels that do not have a state storm water permit within the Bartlett Brook Watershed study area. Parcels that do not have a state stormwater permit are potential areas for non-jurisdictional impervious area growth and are included in the analysis. Additionally, roads are excluded from the analysis and impervious area growth associated with them is addressed in step 6. The 2003 and 2010 impervious surface data was provided by South Burlington. These datasets are polygon based spatial data and identify all types of impervious surface in the watershed. The total non-jurisdictional impervious area for 2003 and 2010 are inputs to step 2 where the average annual rate of growth is calculated. To summarize the total non-jurisdictional impervious area for two periods within non-jurisdictional parcels first clip the impervious area to the parcels that do not have a state storm water permit and then total the impervious area mapped for these two time periods.

Later in this analysis the rate of growth is applied to each parcel to determine additional impervious surface created in 2025, so the existing (2010) impervious area needs to be

assigned to the parcel it falls within. To do this, run the dissolve tool on the 2010 non-jurisdictional impervious area. Then run the intersect tool on the dissolved impervious area and the parcel data to essentially divide the impervious area by parcel boundaries and to bring the parcel ID into the non-jurisdictional impervious area. Finally, do a join from the parcels to this newly created impervious surface data using the “parcel num” field.

2. Determine the annual rate of change for non-jurisdictional impervious area between two time periods.
 - a. The total amount of non-jurisdictional impervious area for 2003 and 2010 is used in this step. The formula for calculating the growth rate is $(\text{Power}((\text{end value}/\text{start value}), (1/N)) - 1) * 100$. The end value is the total impervious area for the watershed in the City for the latest year. The start value is the total impervious area for the earliest year. **According to this method, non-jurisdictional impervious area has increased 1.02% per year in the Bartlett Brook Watershed.** Later in the analysis this rate of growth will be applied to each parcel to estimate the amount of impervious area created in 2025.

Table 1: Existing Non-Jurisdictional Impervious Area, Average Annual Rate of Change

Non Jurisdictional Impervious Acres, 2003	Non Jurisdictional Impervious Acres, 2010	Number of Years	Avg. Ann Change	Change (acres) 2003 to 2010	2025 Projected Total	2025 Additional Growth
45.2	48.5	7	1.02%	3.3	56.4	7.9

3. Apply the impervious area growth rate from step 2 to each parcel within the study area to determine the acreage of non-jurisdictional impervious growth potential in 2025.
 - a. Impervious area for each parcel cannot exceed the lot coverage per municipal regulations.
 - Look up the lot coverage on each parcel in the zoning regulations and assign the lot coverage based on the zoning district each parcel falls within.
 - Determine if a parcel can add more impervious area by dividing existing impervious and the total parcel acreage to get the current existing impervious percent.
 - If existing lot coverage does NOT exceed zoning lot coverage then estimate the total future impervious area in 2025. The formula for this is $(1 + \text{growth rate})^{(\text{future year} - \text{recent year})} * \text{recent year's impervious area}$. Parcels in the GIS data are flagged as 1 in the [AddMoreImp] field if there is the potential to add more impervious cover. If parcels have exceeded the lot coverage and cannot be developed any further they received a 0 in the [AddMoreImp] field. If a parcel does not have any existing impervious area then it is assigned a 2 in [AddMoreImp] field. The future

impervious parcels that are currently undeveloped are assumed to reach their full lot coverage potential in 2025. Therefore, the formula for estimated future impervious area is [Parcel Acres]*Lot Coverage for parcels that are classified as 2 in the [AddMoreImp] field.

- b. Determine if the percent of impervious area by parcel in 2025 is greater than the lot coverage, if lot coverage is exceeded in 2025 then use the remaining lot coverage percentage to estimate the growth. The formula is

$(\text{lot coverage} - (\text{existing lot area} / \text{parcel area}) * \text{parcel} + \text{existing impervious area}.$

4. Use the resulting impervious values for 2025 estimated in step 3 to determine whether the parcel will be jurisdictional or non-jurisdictional. Parcels are “jurisdictional” if the sum of the existing and projected future impervious growth is greater than 1 acre. If a parcel’s total future impervious area is less than 1 acre then the new impervious is considered “non-jurisdictional”. The increase in new impervious area on the parcels with build out potential is shown in the table 2 below and is an estimate of the likely non-jurisdictional impervious area growth for the watershed by 2025.

Table 2: 2025 Total Projected Impervious Area by Type

	Existing ¹ Impervious Area (acres)	Estimated 2025 Total Impervious Area (acres)	New Non- Jurisdictional Additional Impervious Area (acres)
Jurisdictional	9.5	13.5	4.0
Non Jurisdictional	33.8	39.5	5.7
Grand Total for Watershed	43.3	53.0	9.7

1-The existing impervious area in this table is lower than in table 1 because this table only reports existing impervious area on parcels that have development potential and have not exceeded the lot coverage standard.

5. Estimate the total impervious area potential on a parcel based on lot coverage. The formula for this is $(\text{Lot Cov} - \text{Existing \% imp area}) * \text{parcel area} + \text{existing imp area}$. The estimate of total impervious area will assist in the identification of parcels that could become jurisdictional if a large development is planned and developed all at once. Table 3 shows the amount of impervious area possible if every parcel built out to the maximum lot coverage independent of time.

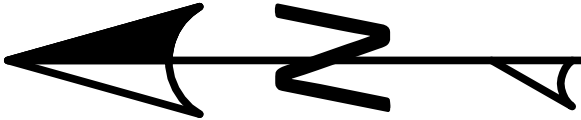
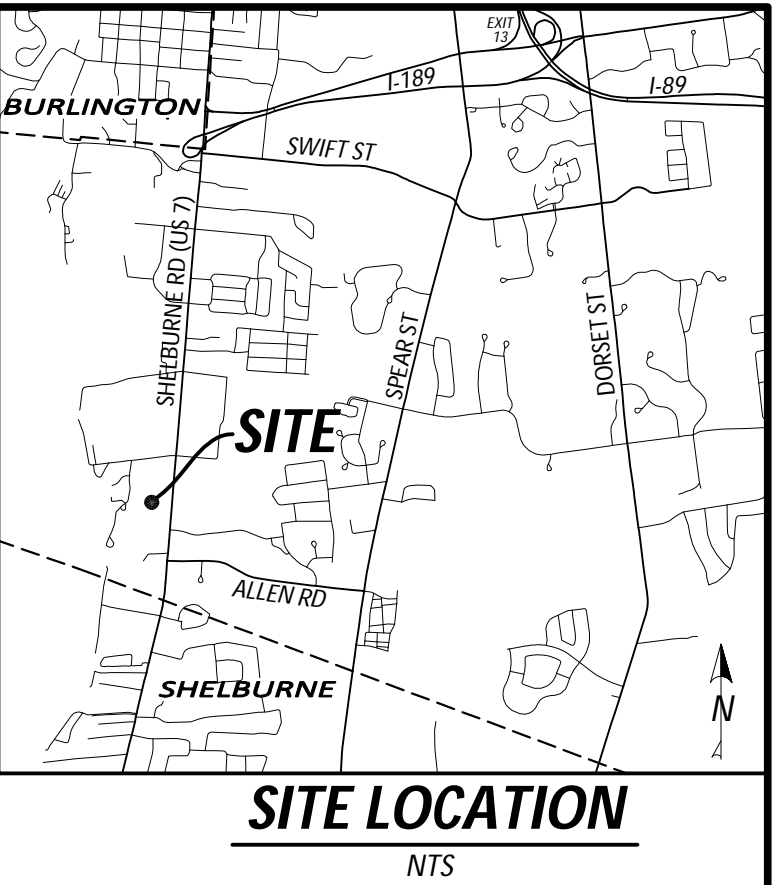
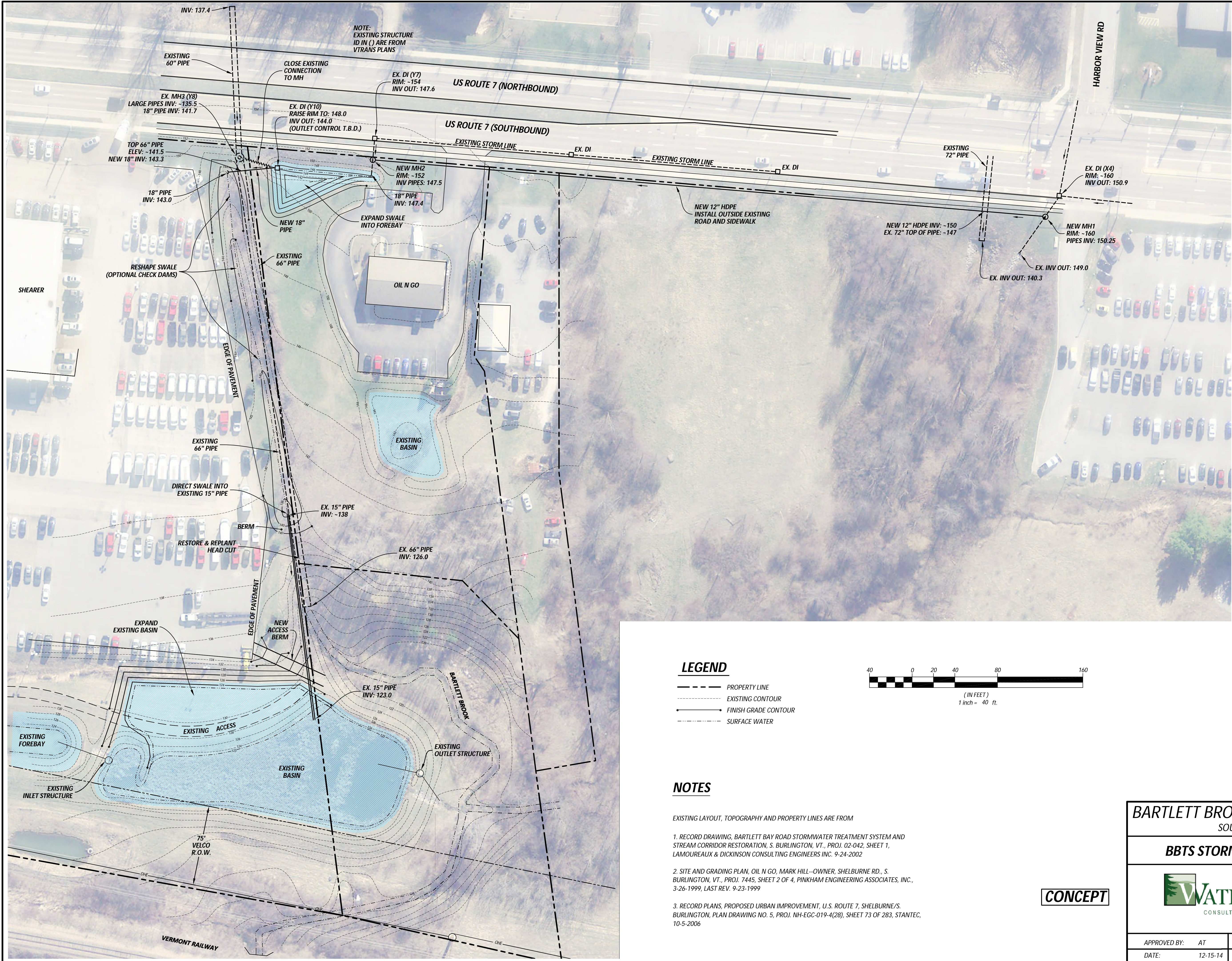
Table 3: Total Impervious Area for Parcels that do not have an existing State Stormwater Permit

	Existing Impervious Area (acres)	Total Impervious Area (Remaining Lot Coverage)	Difference Between Total Imp Area & Existing
Jurisdictional	15.1	171.5	156.5
Non Jurisdictional	28.2	63.0	34.8
Grand Total for Watershed	43.3	234.6	191.3

6. Roads were not included in this analysis because they are not built out in the same manner as parcels and are not subject to lot coverage requirements. Any new roads in this watershed are likely to be for access to large future developments on larger parcels. Also any new expansions or sidewalk additions will likely put the impervious area threshold over 1 acre making the road subject to state stormwater standards.

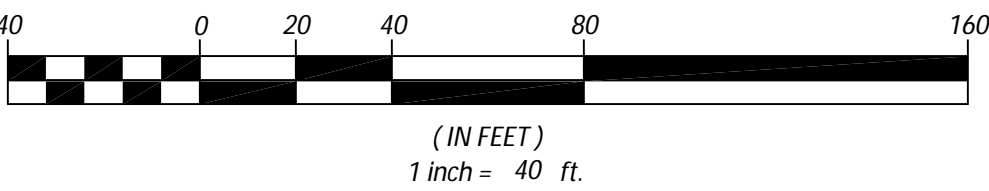
APPENDIX 2

**30% ENGINEERING PLANS FOR THE TOP 4 PROJECTS IN
BARTLETT BROOK &
ORTHOPHOTO-BASED SKETCH PLANS**



LEGEND

- PROPERTY LINE
- EXISTING CONTOUR
- FINISH GRADE CONTOUR
- SURFACE WATER



NOTES

- EXISTING LAYOUT, TOPOGRAPHY AND PROPERTY LINES ARE FROM
1. RECORD DRAWING, BARTLETT BAY ROAD STORMWATER TREATMENT SYSTEM AND STREAM CORRIDOR RESTORATION, S. BURLINGTON, VT., PROJ. 02-042, SHEET 1, LAMOUREAUX & DICKINSON CONSULTING ENGINEERS INC. 9-24-2002
 2. SITE AND GRADING PLAN, OIL N GO, MARK HILL--OWNER, SHELBURNE RD., S. BURLINGTON, VT., PROJ. 7445, SHEET 2 OF 4, PINKHAM ENGINEERING ASSOCIATES, INC., 3-26-1999, LAST REV. 9-23-1999
 3. RECORD PLANS, PROPOSED URBAN IMPROVEMENT, U.S. ROUTE 7, SHELBURNE/S. BURLINGTON, PLAN DRAWING NO. 5, PROJ. NH-EGC-019-4(28), SHEET 73 OF 283, STANTEC, 10-5-2006

CONCEPT

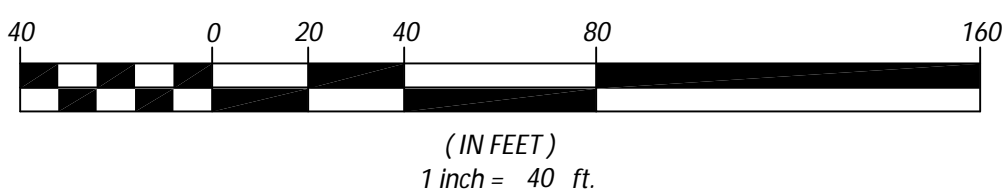
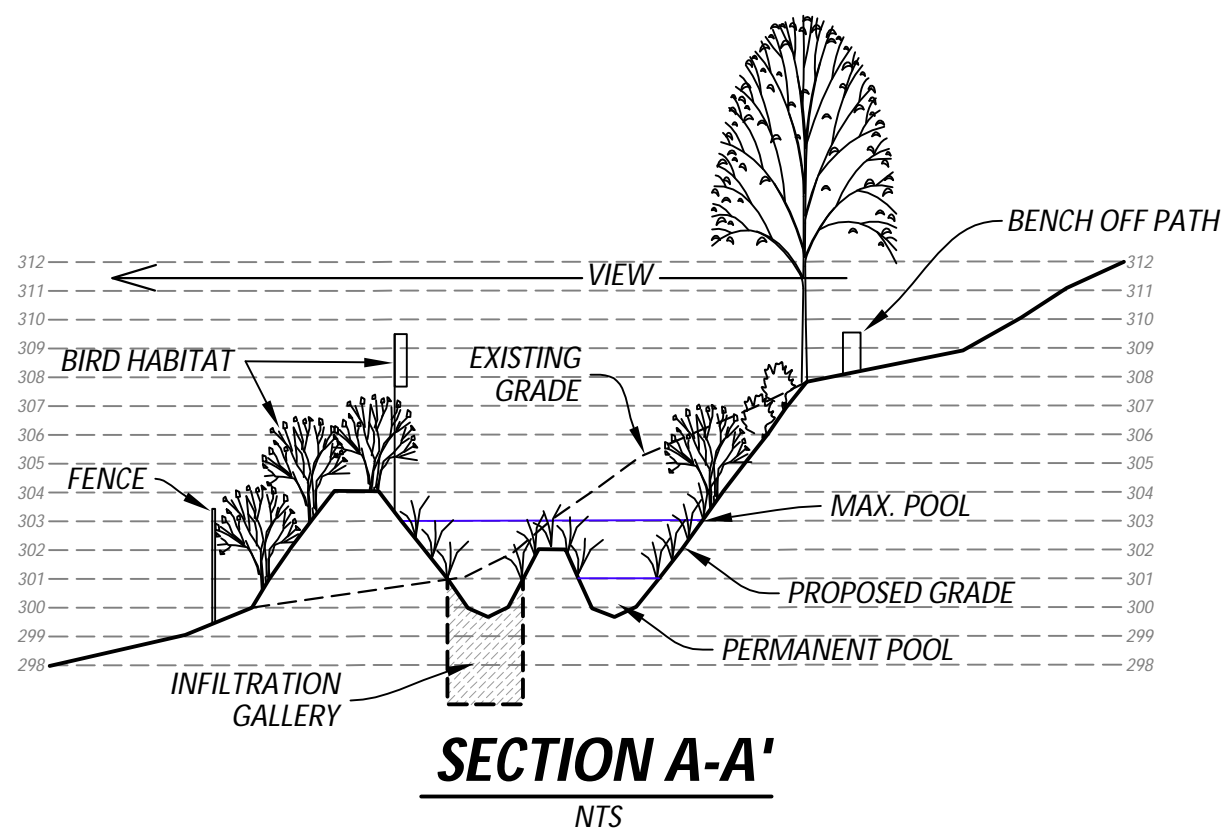
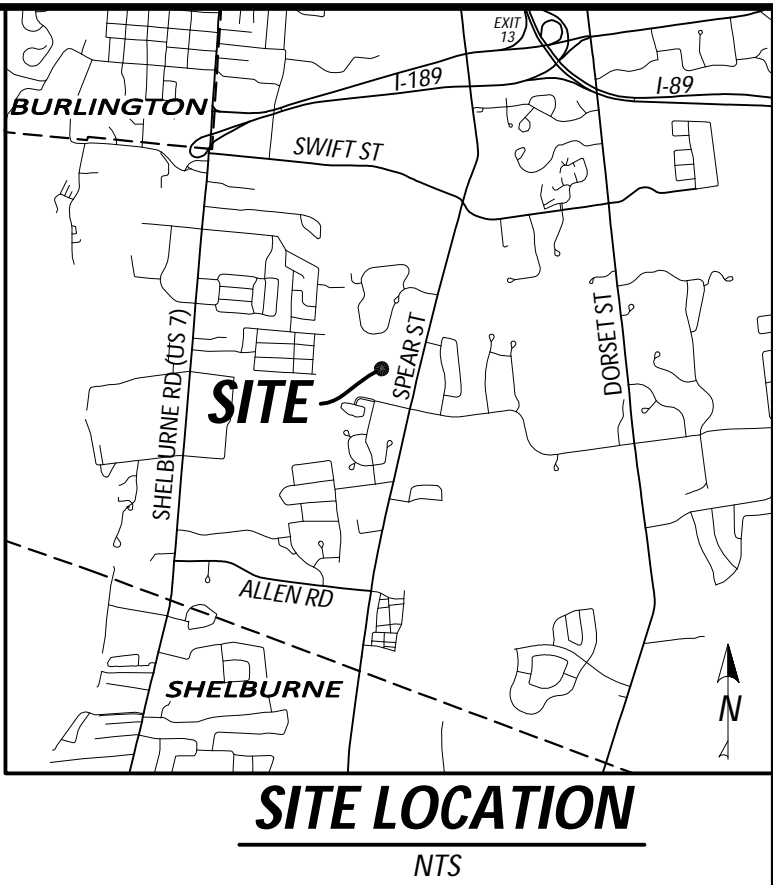
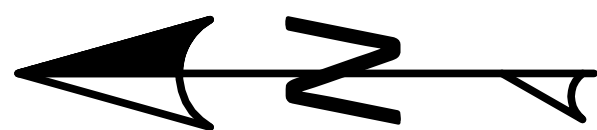
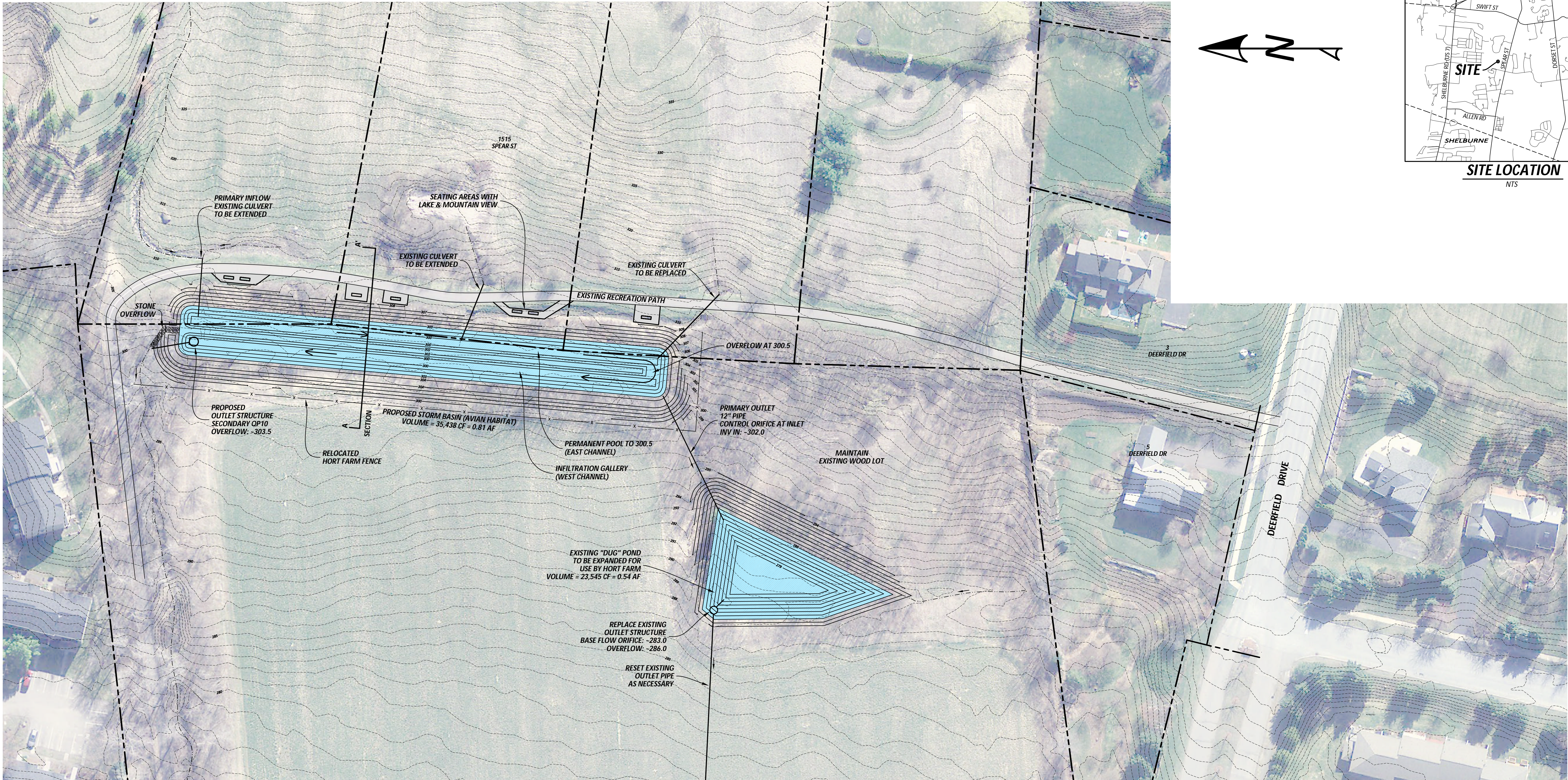
BARTLETT BROOK FLOW RESTORATION PLAN
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BBTS STORMWATER IMPROVEMENT PLAN



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DATE:	12-15-14	CHECKED BY:	AT	SHEET:	1 OF 1



LEGEND

- PROPERTY LINE
- - - EXISTING CONTOUR
- FINISH GRADE CONTOUR
- - - DRAINAGE COURSE

NOTES

1. THIS IS NOT A BOUNDARY SURVEY. BOUNDARY INFORMATION IS FROM TOWN TAX MAPS.
2. EXISTING TOPOGRAPHY WAS CREATED FROM CHITTENDEN COUNTY LIDAR (2004).

CONCEPT

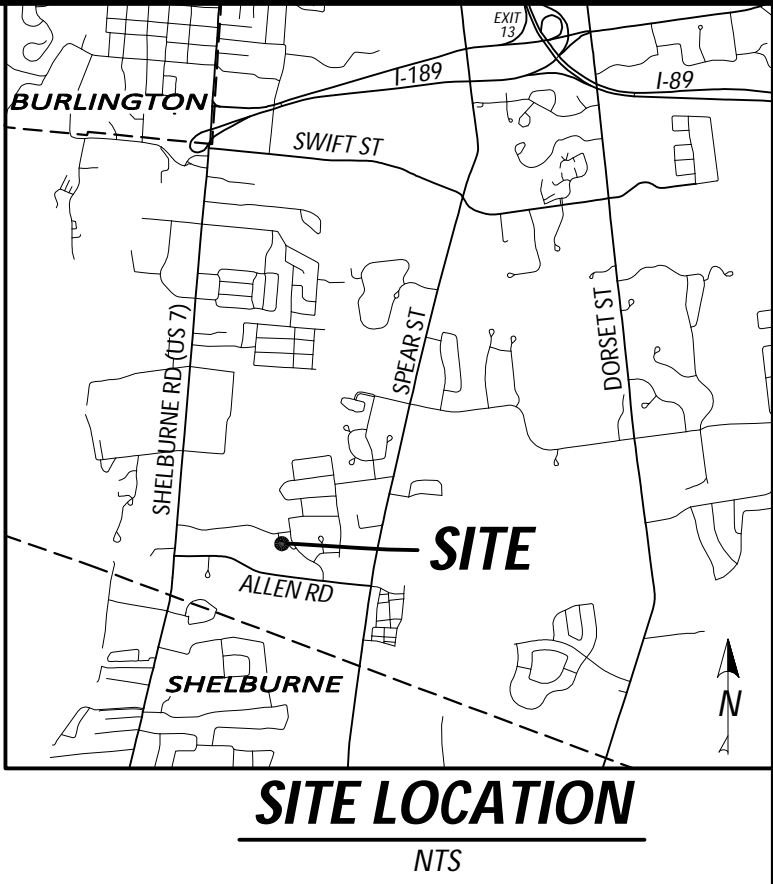
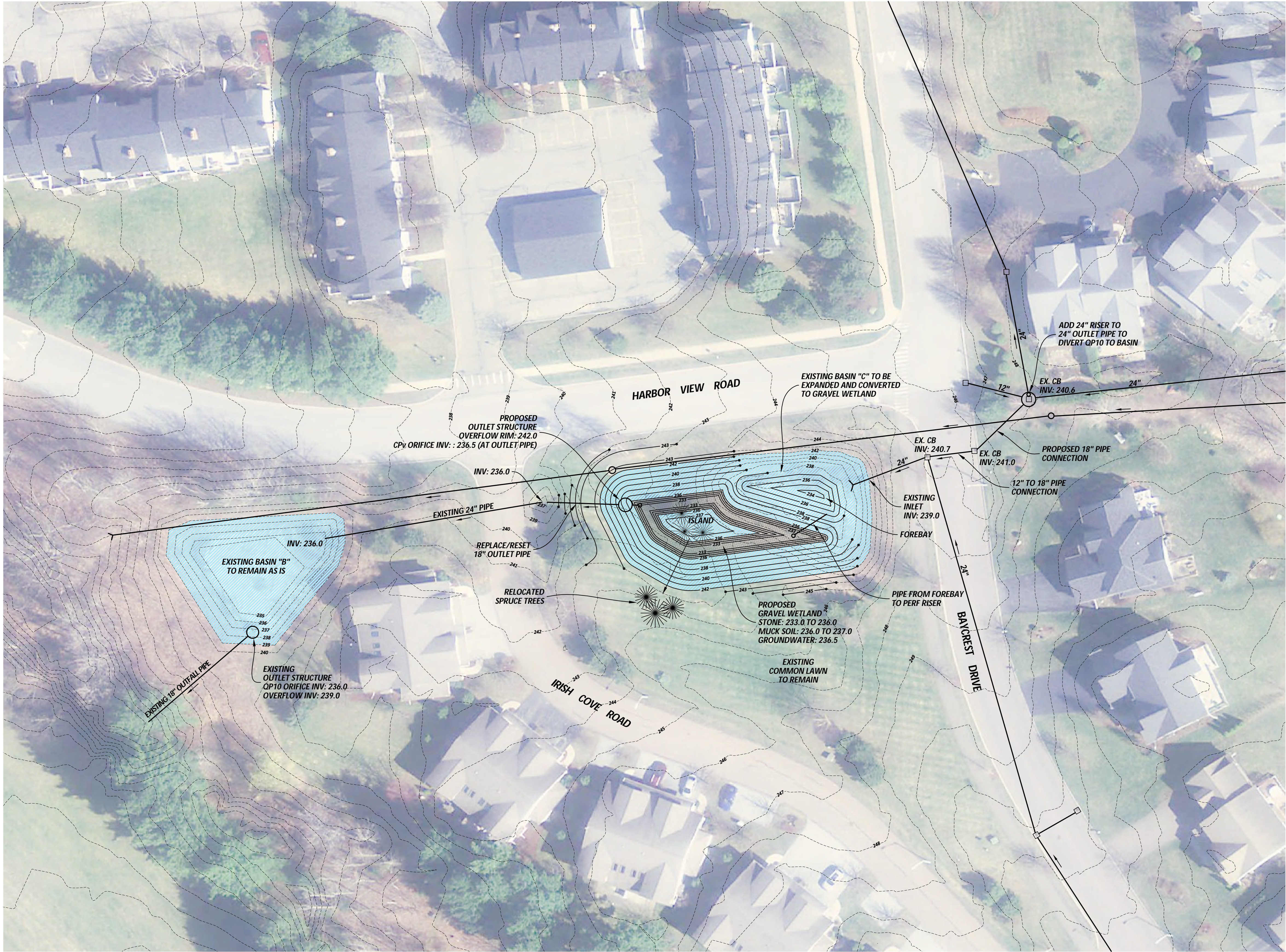
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HORT FARM STORMWATER IMPROVEMENT PLAN



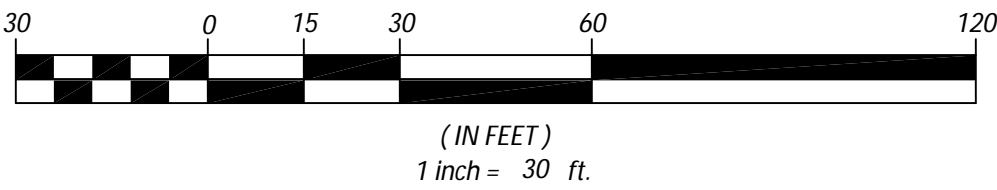
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LEGEND

- EXISTING CONTOUR
- FINISH GRADE CONTOUR



NOTE

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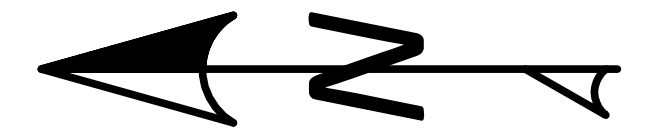
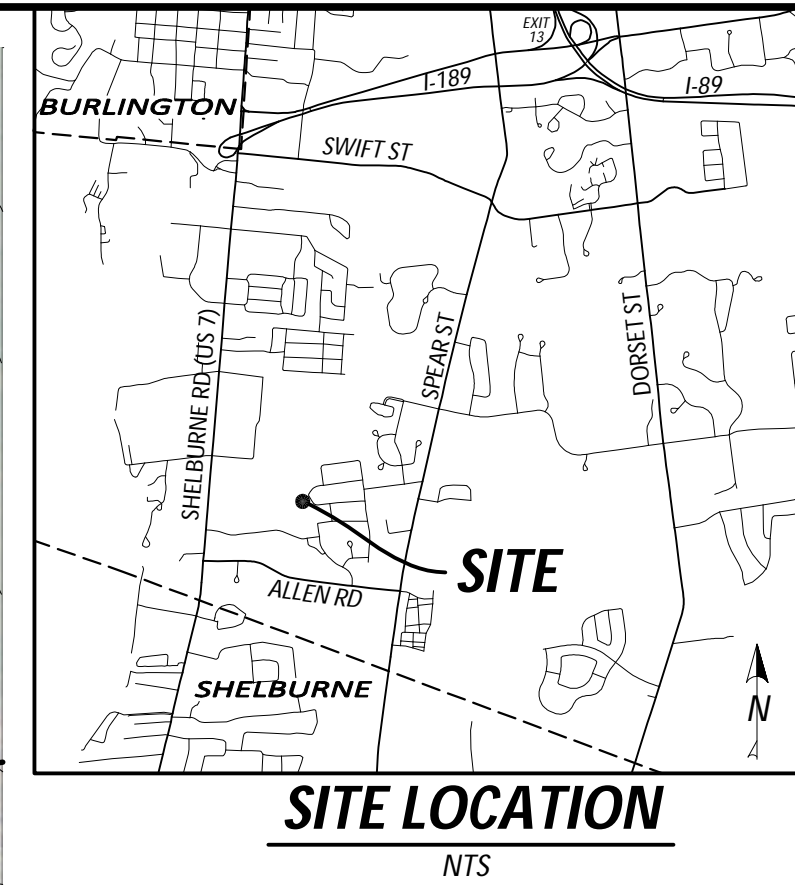
BARTLETT BROOK FLOW RESTORATION PLAN
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IRISH FARM STORMWATER IMPROVEMENT PLAN

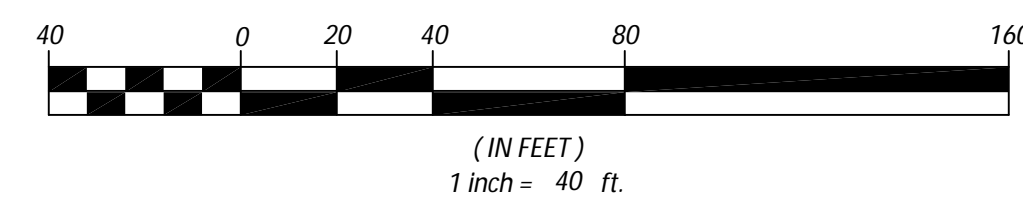


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- LEGEND**
- PROPERTY LINE
 - EXISTING CONTOUR
 - EXISTING STORM LINE
 - PROPOSED STORM LINE



NOTES

- THIS IS NOT A BOUNDARY SURVEY. BOUNDARY INFORMATION IS FROM TOWN TAX MAPS.
- EXISTING TOPOGRAPHY WAS CREATED FROM CHITTENDEN COUNTY LIDAR (2004).

BARTLETT BROOK FLOW RESTORATION PLAN
SOUTH BURLINGTON, VERMONT

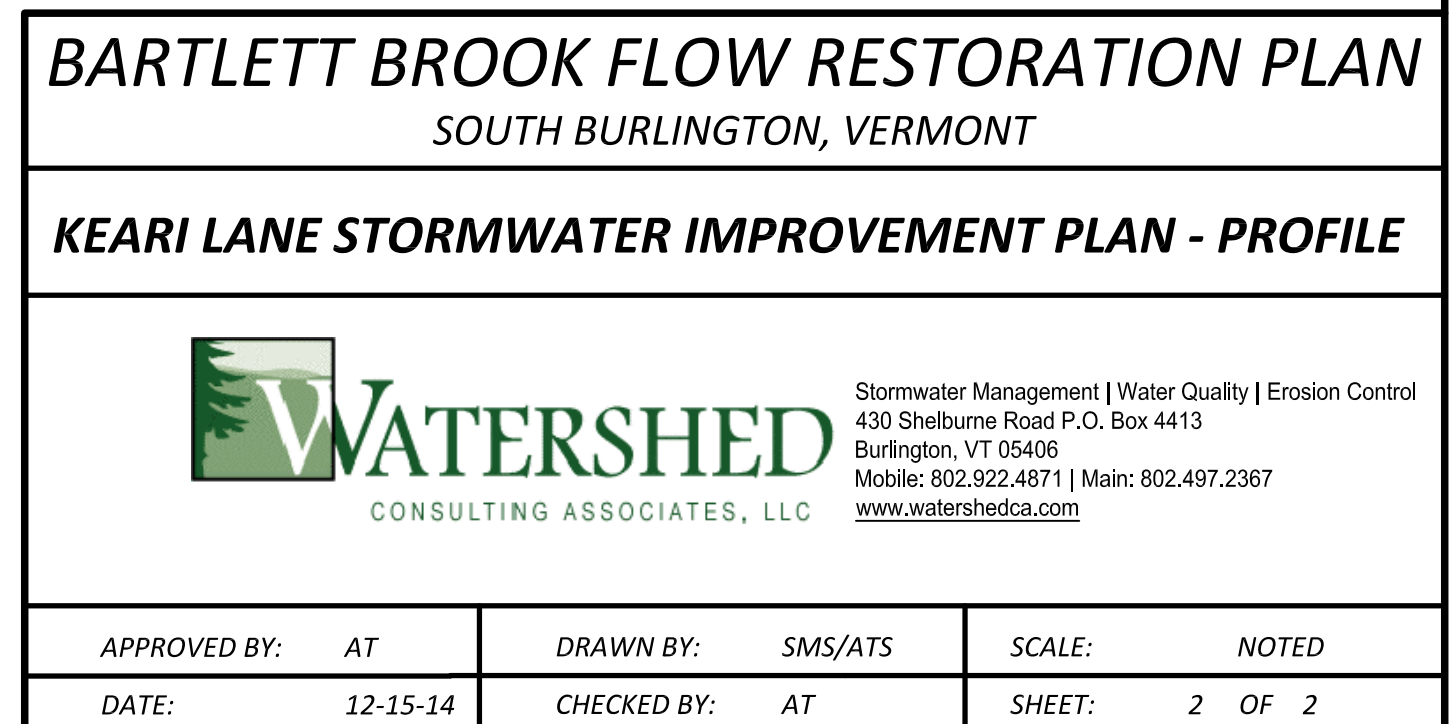
KEARI LANE STORMWATER IMPROVEMENT PLAN

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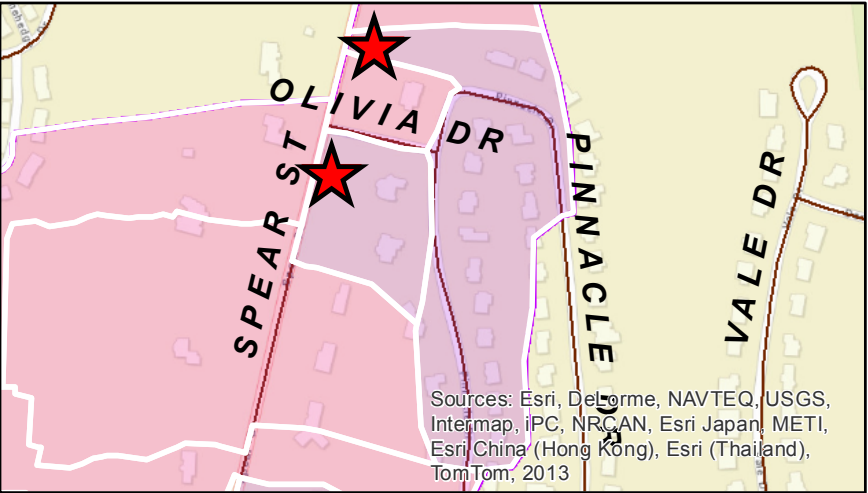
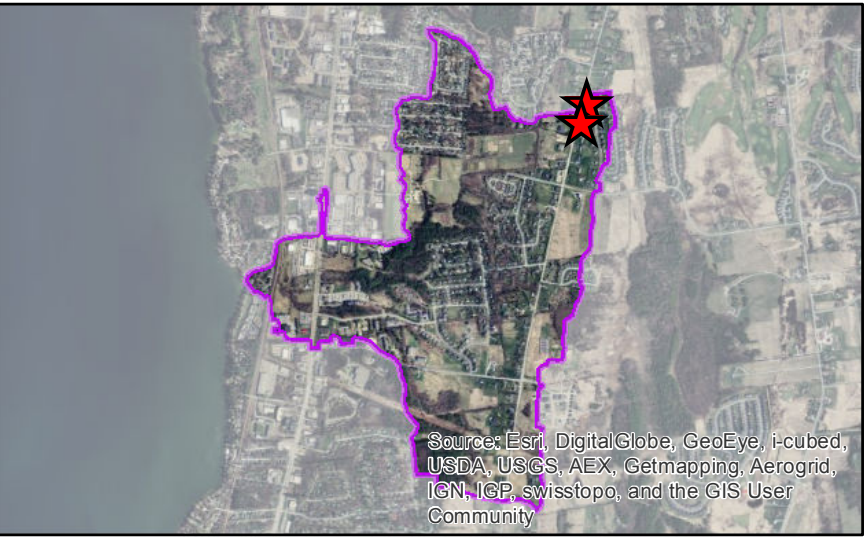
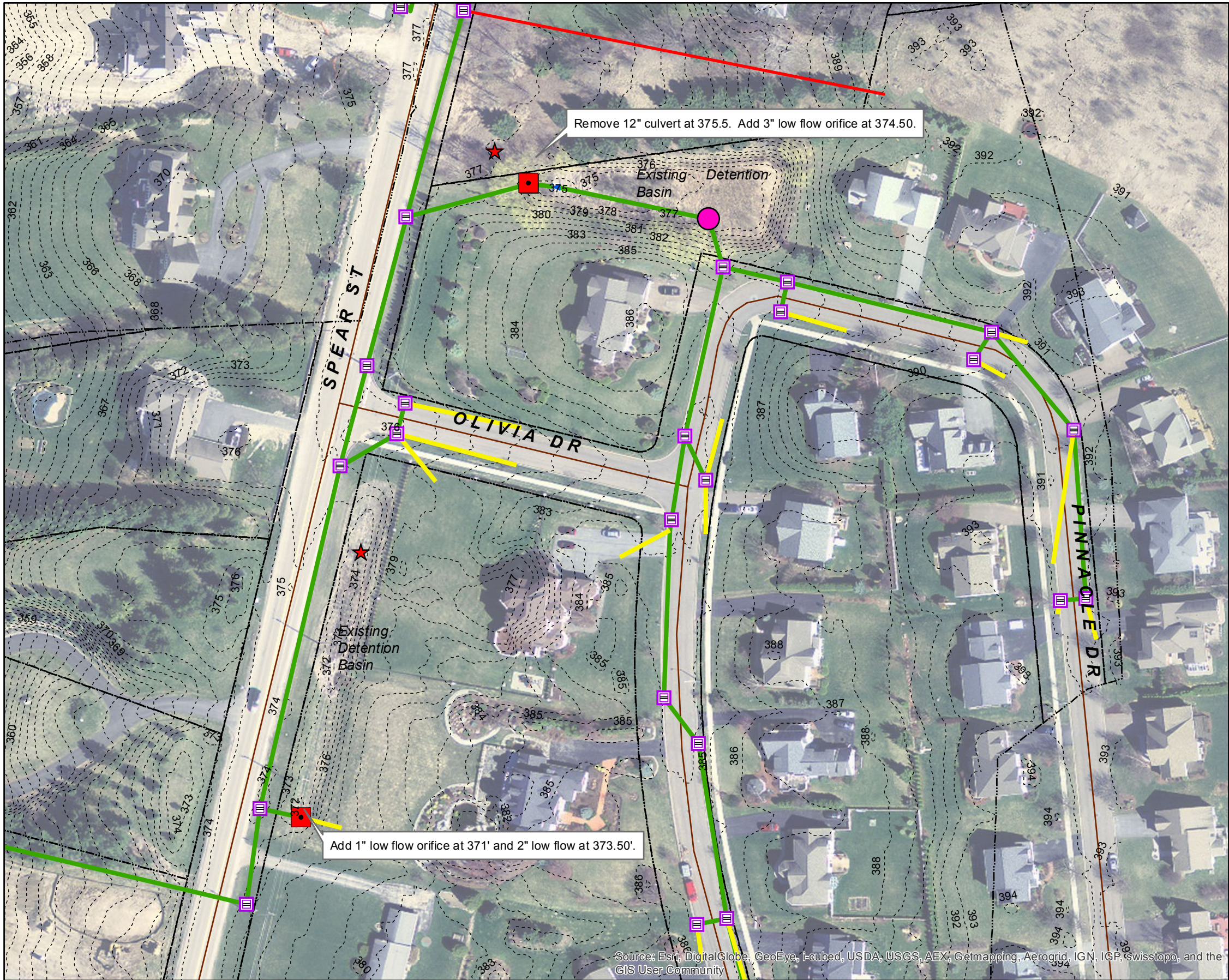


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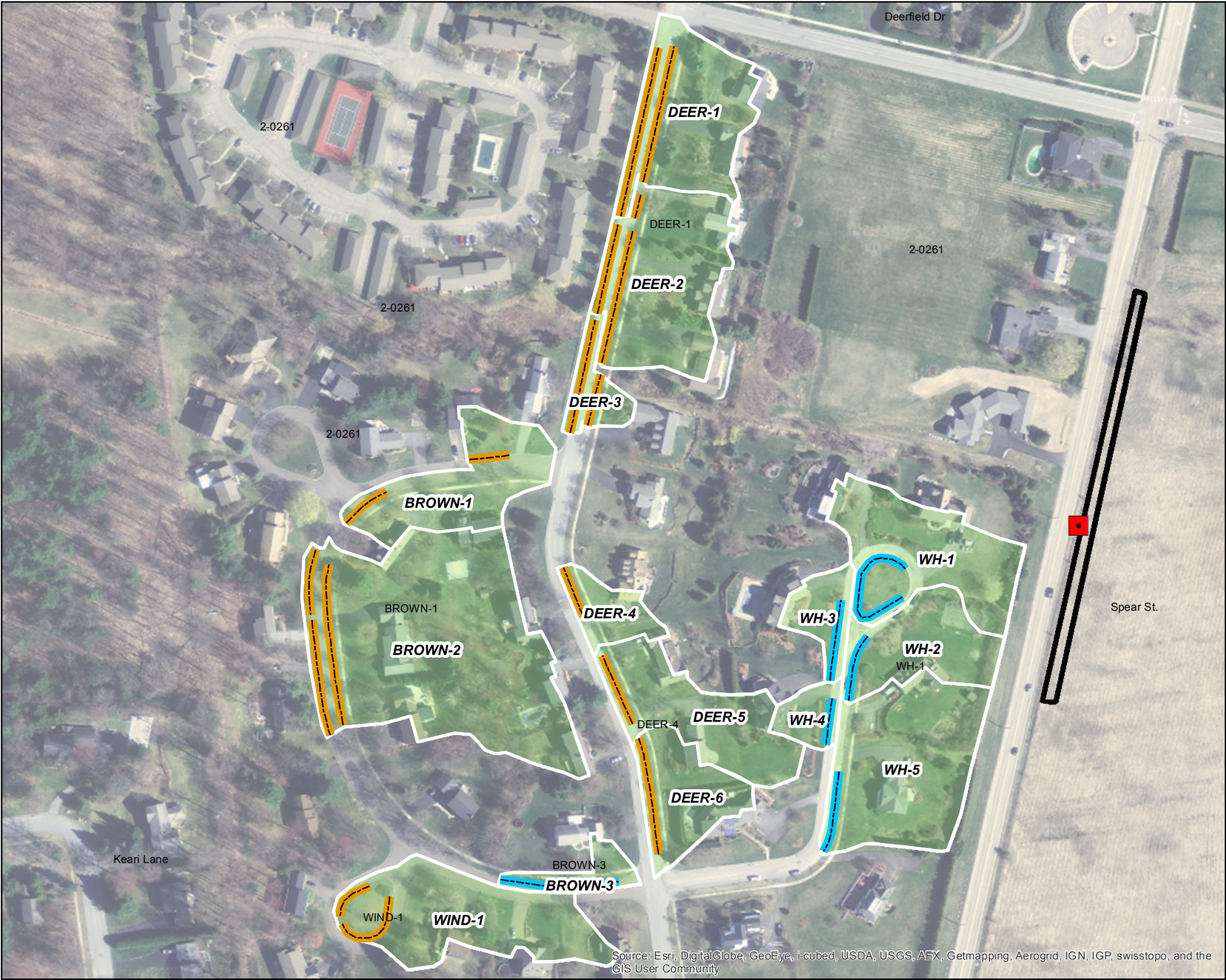
- LEGEND**

 - ★ PROPOSED RETROFIT SITE
 - PROPOSED OUTLET
 - PROPERTY LINE
 - EXISTING 1' CONTOUR
 - CITY BOUNDARY
 - Roads
- BMP DRAINAGE AREA**

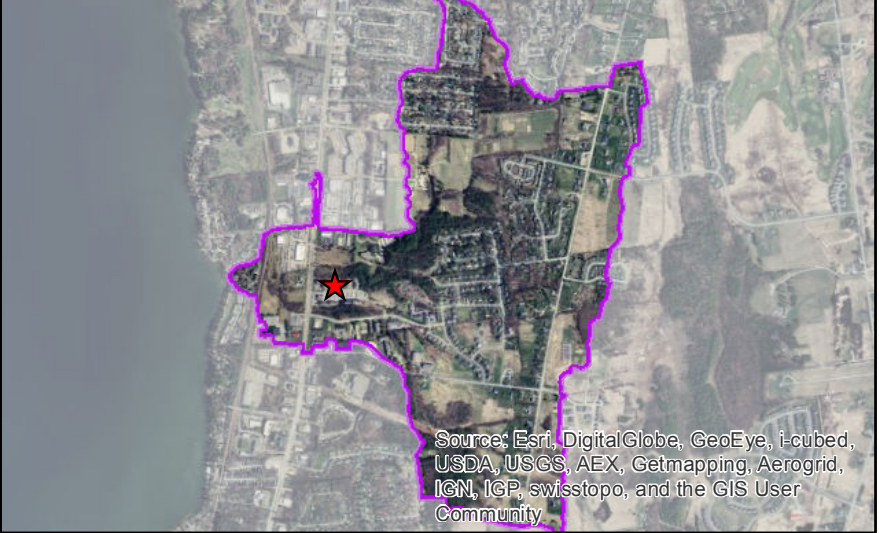
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 - post 2002
 - bartlett_watershed_101414



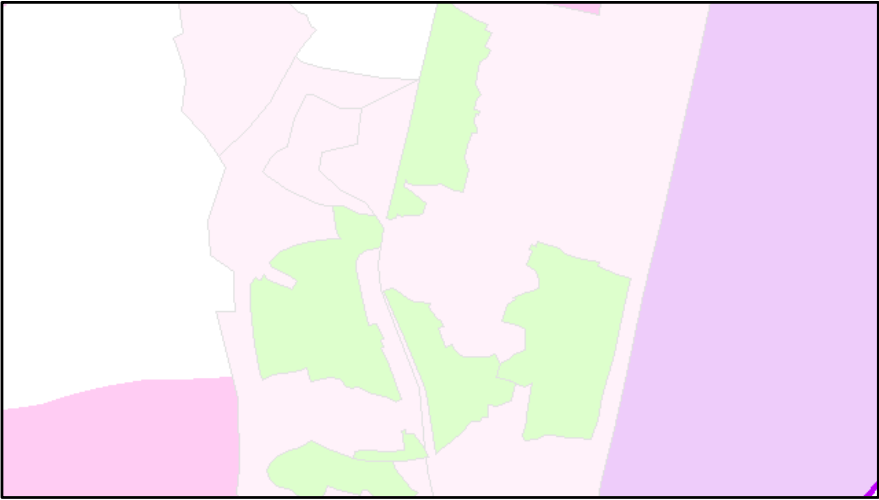
BARTLETT BROOK FLOW RESTORATION STUDY SOUTH BURLINGTON, VERMONT		
1-1155a and 1-1155b Pond Retrofit		
DATE:12-05-14	DRAWN BY:JS	SCALE:NOTED



Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



LEGEND

- ROW Detention Planter
- ROW Infiltration Planter
- PROPOSED OUTLET
- FINISH GRADE 2' CONTOUR
- GSI BMP Drainage Areas

BMP DRAINAGE AREA

- Credit3
- Credit1
- Credit2
- base-r
- base
- post 2002
- bartlett_watershed_101414
- Roads

NOTES:

Locations for proposed GSI practices are approximate. Utility and tree conflicts have not been verified. Detention BMPs were designed as biofilters and in the ROW sized to mitigate the 1-year storm (CPv) volume with underdrains and overflow outlet structures, tied to the existing stormwater system. Infiltration BMPs were designed as bioretention practices, sized to infiltrate the 1-year storm (CPv) volume. Ponding depth for all practices range from 6-8".

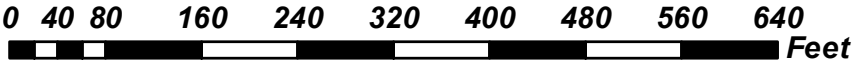
**BARTLETT BROOK FLOW RESTORATION STUDY
SOUTH BURLINGTON, VERMONT**

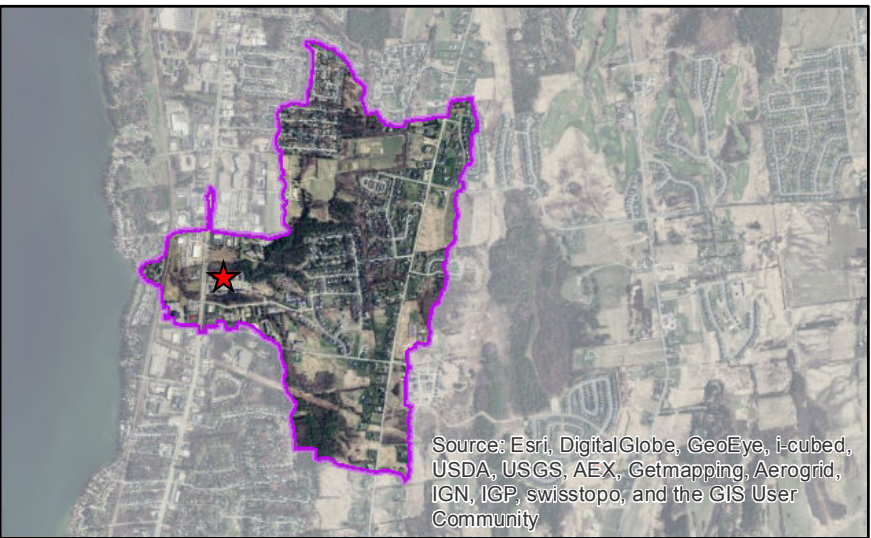
2-0261 Neighborhood Green Stormwater Infrastructure BMPs

DATE: 12-12-14

DRAWN BY:JS

SCALE:NOTED





LEGEND

- PROPOSED OUTLET
- PROPOSED STORMLINE
- FINISH GRADE 2' CONTOUR
- EXISTING 1' CONTOUR
- CITY BOUNDARY
- Roads

BMP DRAINAGE AREA

- Credit3
- Credit1
- Credit2
- base-r
- base
- post 2002
- bartlett_watershed_101414

BARTLETT BROOK FLOW RESTORATION STUDY
SOUTH BURLINGTON, VERMONT

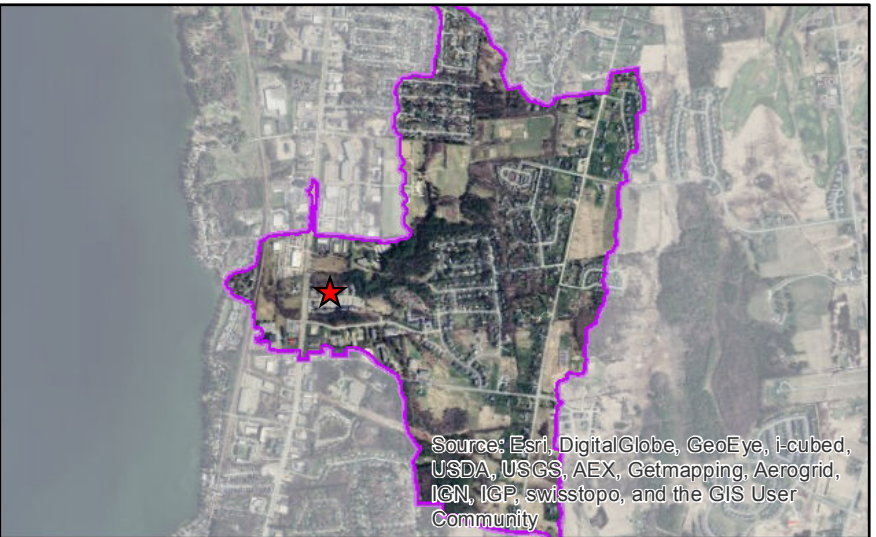
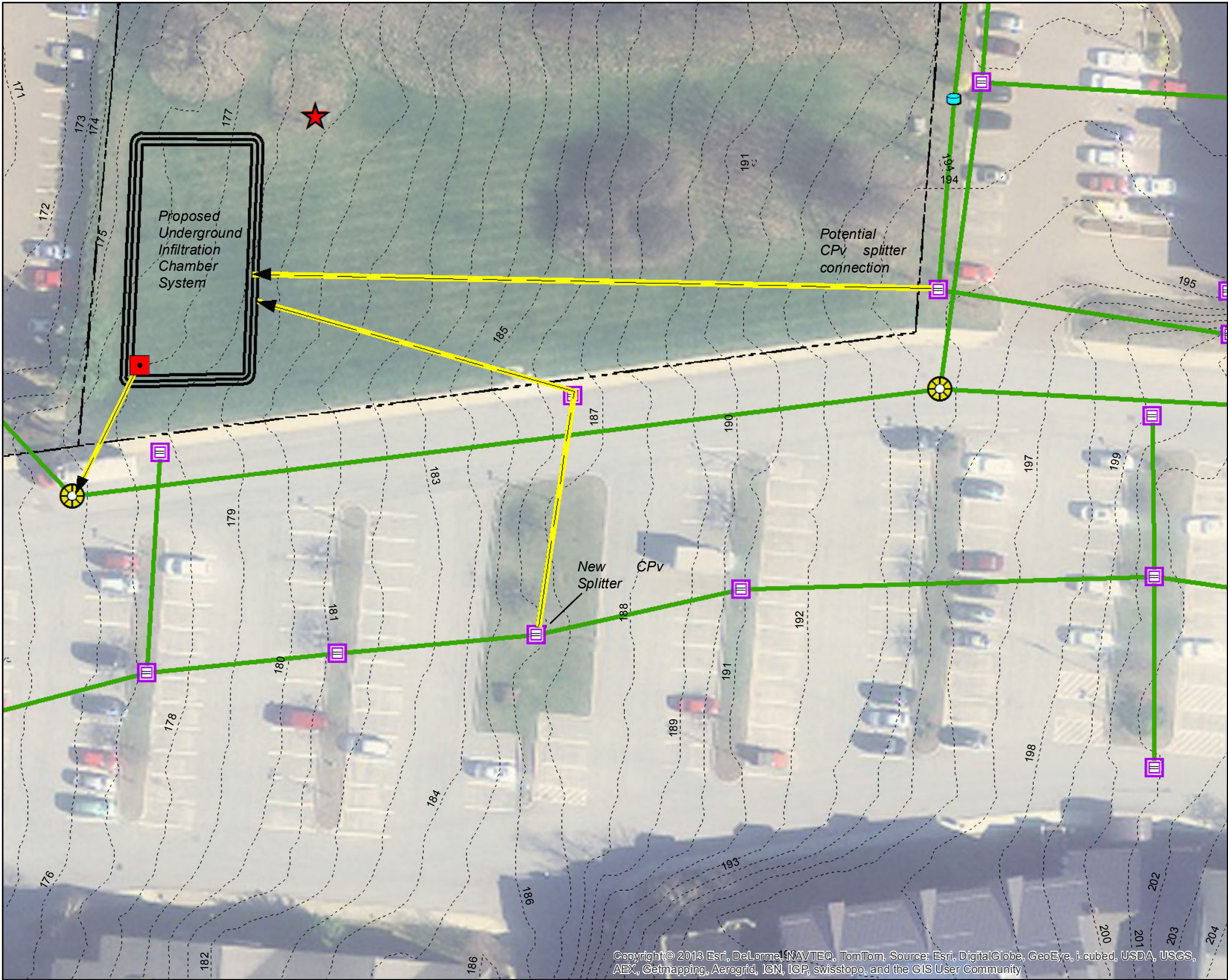
Allen Rd Detention Basin

DATE: 12-12-14

DRAWN BY:JS

SCALE:NOTED





LEGEND

- ★ PROPOSED RETROFIT SITE
- PROPOSED OUTLET
- PROPOSED STORMLINE
- - - PROPERTY LINE
- CITY BOUNDARY
- - - EXISTING 1' CONTOUR

BMP DRAINAGE AREA

- Credit3
- Credit1
- Credit2
- base-r
- base
- post 2002
- bartlett_watershed_101414

NOTES:

The proposed Holiday Inn Project includes an underground infiltration chamber to mitigate the 1-year storm (CPv) runoff from the Holiday Inn Parking lot. An additional CPv connection is proposed to connect the upper Staybridge runoff to the chamber system. Future design of this project should be completed in conjunction with development plans for 1690 Shelburne Rd.

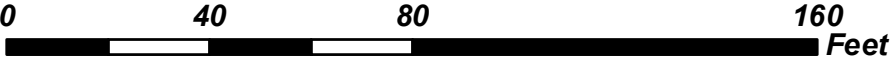
**BARTLETT BROOK FLOW RESTORATION STUDY
SOUTH BURLINGTON, VERMONT**

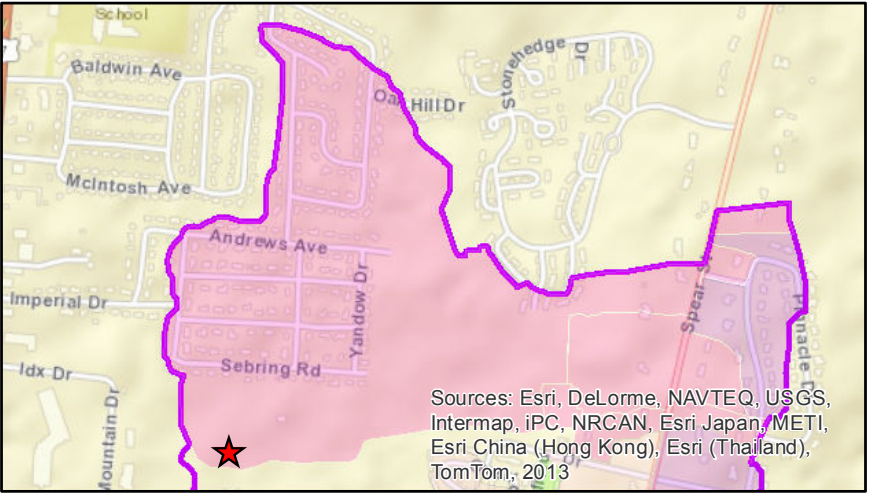
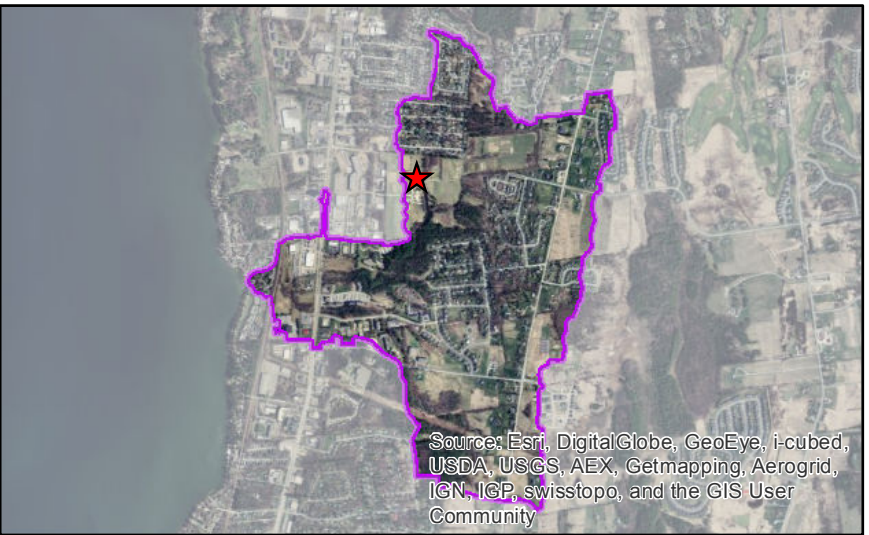
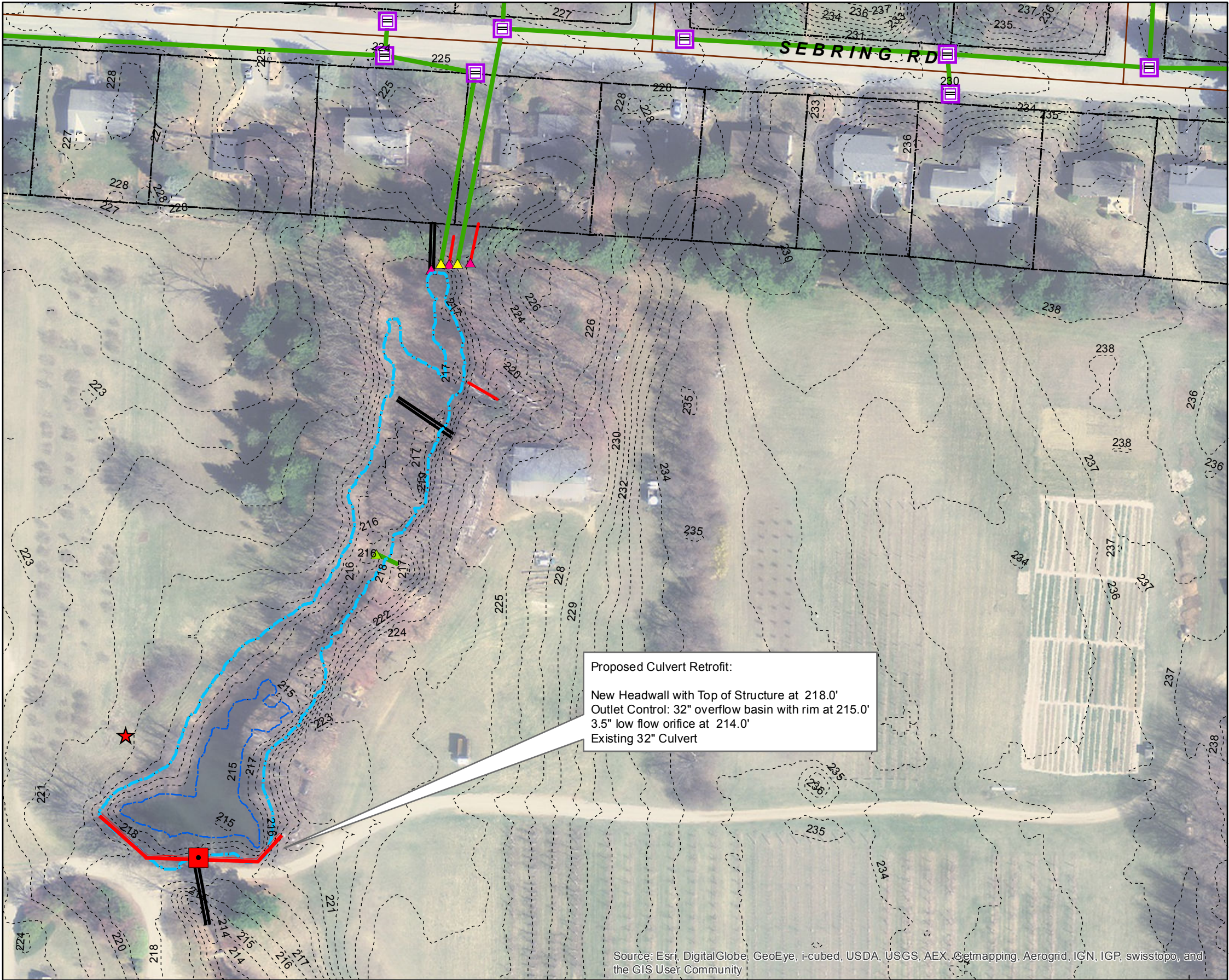
Holiday Inn Lot Stormwater Improvement Plan

DATE: 12-15-14

DRAWN BY:JS

SCALE:NOTED





- LEGEND**

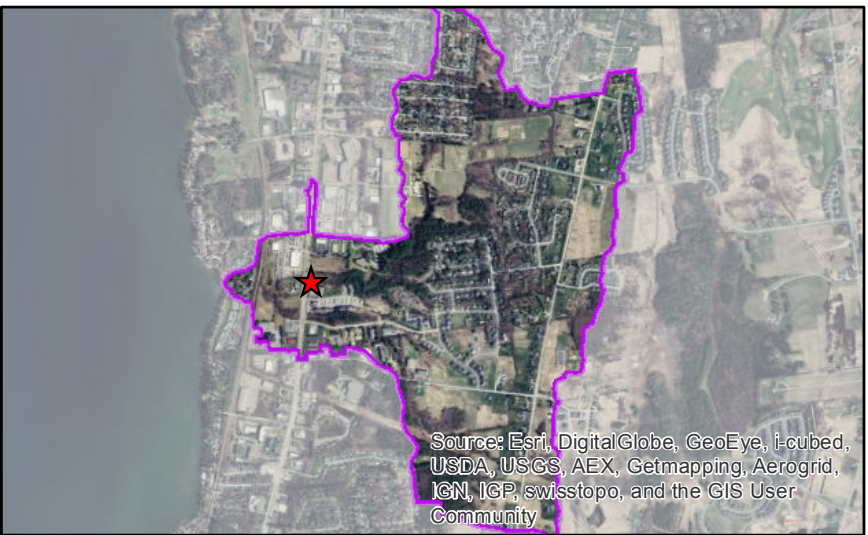
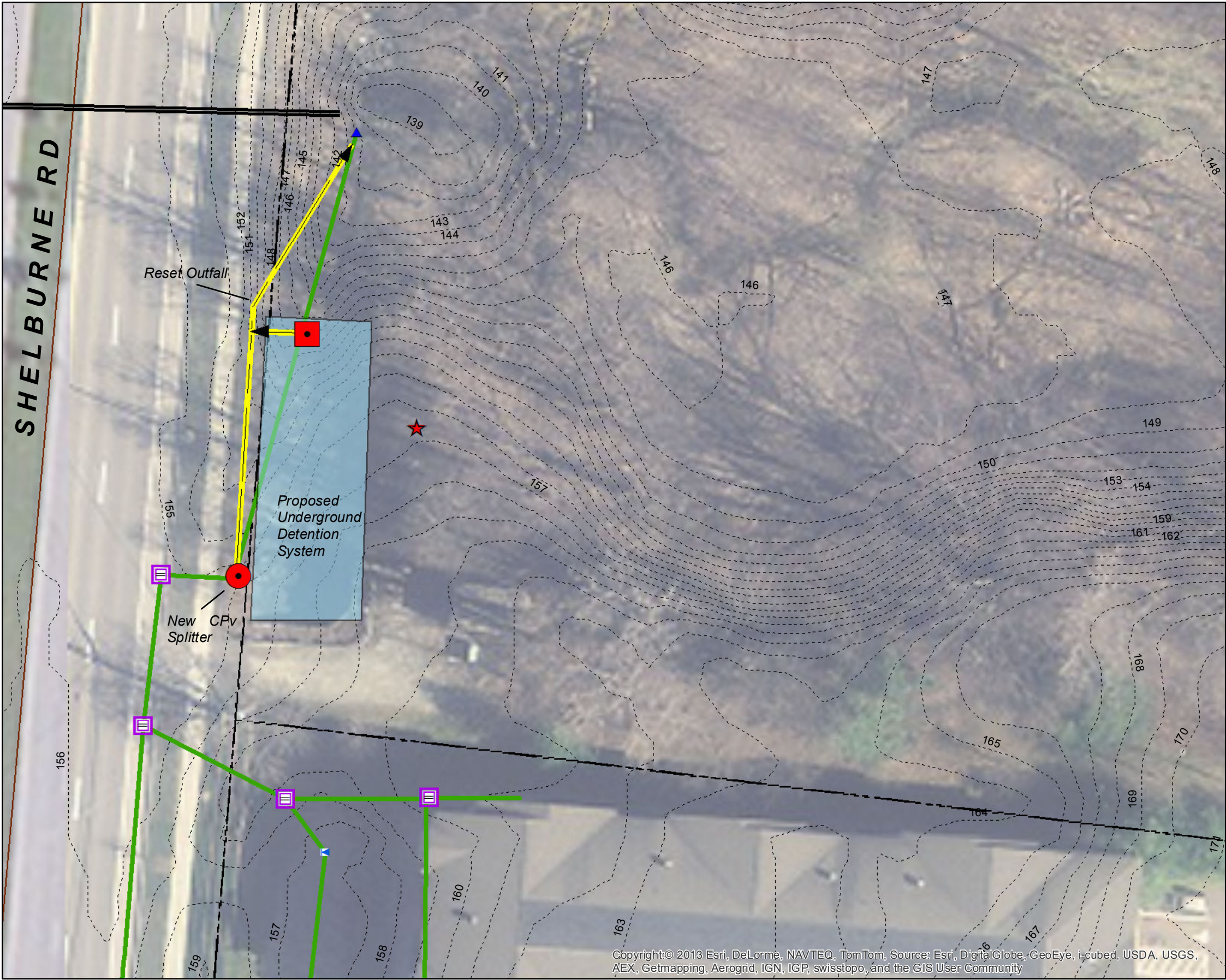
 - ★ PROPOSED RETROFIT SITE
 - PROPOSED OUTLET
 - PROPOSED HEADWALL
 - - - 1-yr (CPv) storage
 - - - 100-yr storage
 - - - PROPERTY LINE
 - - - EXISTING 1' CONTOUR
 - CITY BOUNDARY
 - Roads
- BMP DRAINAGE AREA**

 - Credit3
 - Credit1
 - Credit2
 - base-r
 - base
 - post 2002
 - bartlett_watershed_101414

NOTES:
The Laurel Hill Culvert project involves a retrofit of the existing 32" culvert to provide additional storage. Proposed changes include addition of a new concrete headwall and outlet basin with a low-flow orifice and overflow for Channel Protection volume (CPv) storage.

BARTLETT BROOK FLOW RESTORATION STUDY SOUTH BURLINGTON, VERMONT		
Laurel Hill Development Culvert Retrofit		
DATE: 12-12-14	DRAWN BY:JS	SCALE:NOTED





LEGEND

- ★ PROPOSED RETROFIT SITE
- PROPOSED STORM MANHOLE
- PROPOSED OUTLET
- ➡ PROPOSED STORMLINE
- Proposed Underground Detention Chamber
- ▭ PROPERTY LINE
- - - EXISTING 1' CONTOUR
- ▭ CITY BOUNDARY
- Roads

BMP DRAINAGE AREA

- Credit3
- Credit1
- Credit2
- base-r
- base
- post 2002
- bartlett_watershed_101414

NOTES:

The proposed Shelburne Rd/Route 7 BMP involves an underground detention chamber to mitigate the 1-year storm (CPv) volume. The existing outfall would be reset.



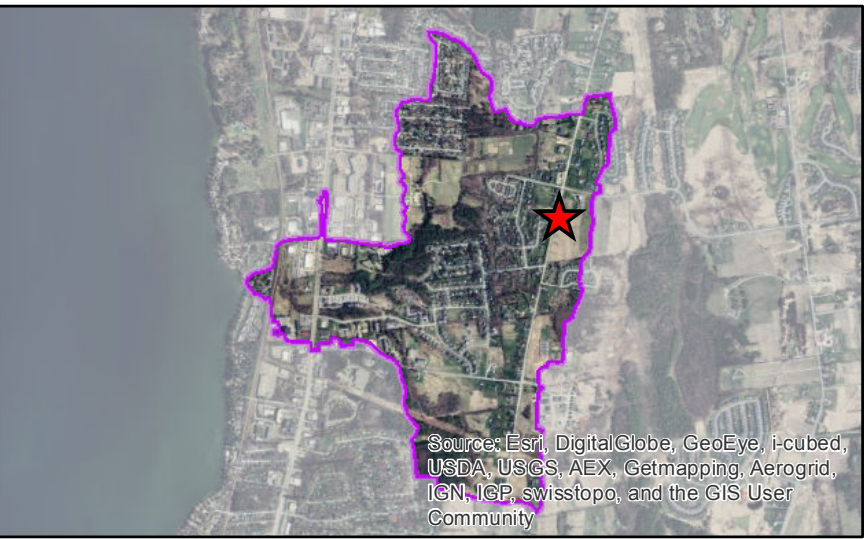
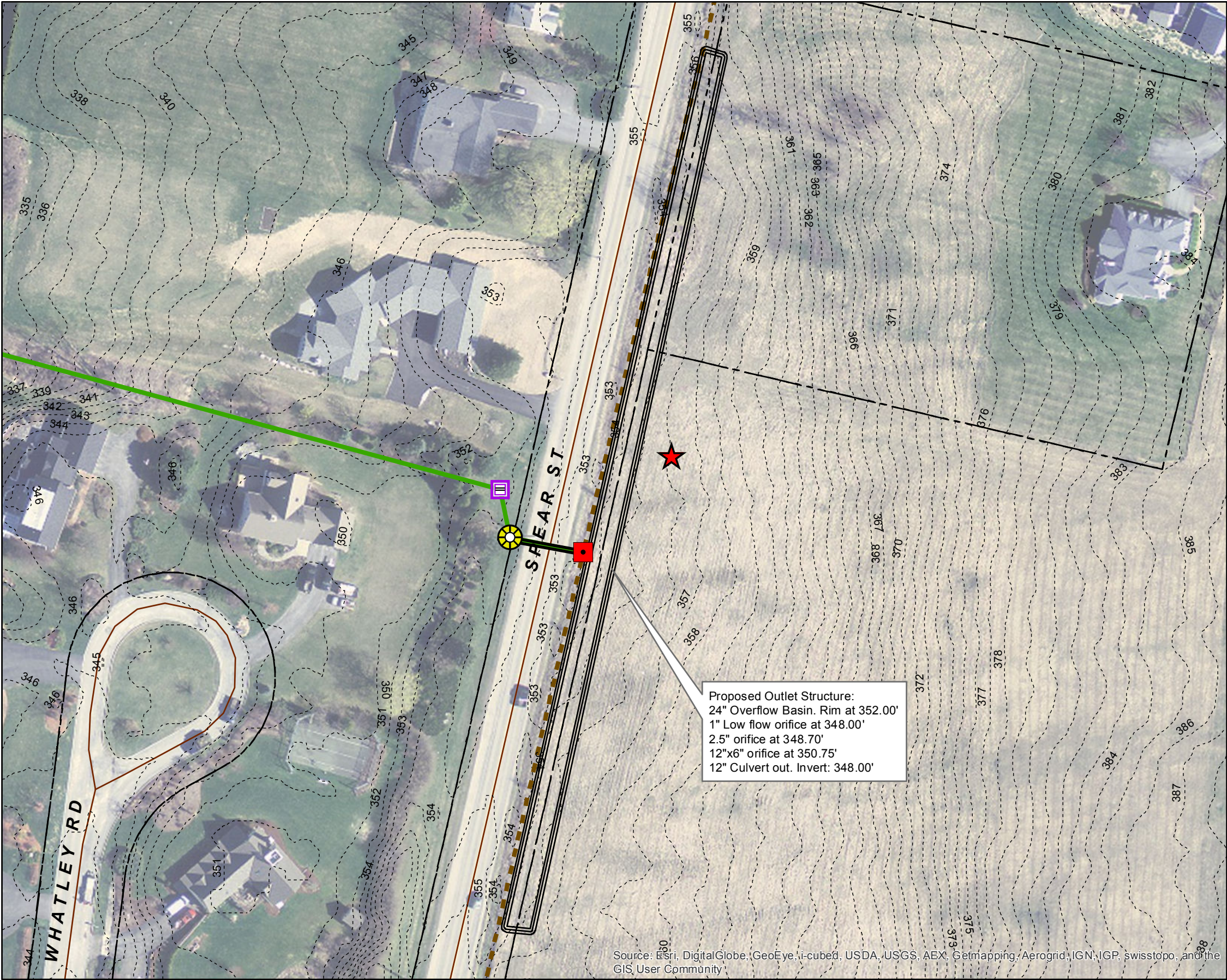
**BARTLETT BROOK FLOW RESTORATION STUDY
SOUTH BURLINGTON, VERMONT**

Shelburne Rd Detention Chamber BMP

DATE: 12-12-14

DRAWN BY:JS

SCALE:NOTED



- LEGEND**

 - ★ PROPOSED RETROFIT SITE
 - PROPOSED OUTLET
 - FINISH GRADE 2' CONTOUR
 - PROPERTY LINE
 - - - EXISTING 1' CONTOUR
 - CITY BOUNDARY
 - Roads
- BMP DRAINAGE AREA**

 - Credit3
 - Credit1
 - Credit2
 - base-r
 - base
 - post 2002
 - bartlett_watershed_101414

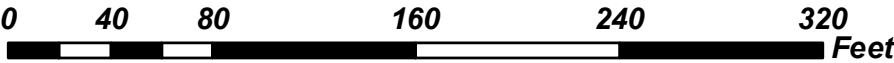
NOTES:

The Spear St. Stormwater BMP project is currently being designed to final engineering by Stantec under a contract with the City of South Burlington. The BMP presented in this plan is a conceptual design included in the Flow Restoration Plan (FRP) Analysis to provide Channel Protection volume (CPv) storage.

BARTLETT BROOK FLOW RESTORATION STUDY
SOUTH BURLINGTON, VERMONT

Spear St. CPv Detention Basin

DATE: 12-12-14	DRAWN BY: JS	SCALE: NOTED
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APPENDIX 3

TABLE A-3-1: BMPDSS MODELING SUMMARY

TABLE A-3-2: BMP TABLE

Bartlett Brook Flow Restoration Plan (FRP) Project
 Task 4: BMPDSS Model Summary
 December 30th, 2014



Model Run	Description	High Flow Reduction (%)	Low Flow Increase (%)	BMPDSS Model Run Date
TMDL Targets with 50 acres of Non-Jurisdictional Future Growth		-33.20	13.20	----
TMDL Modified Targets with 5.7 acres of Non-Jurisdictional Future Growth		-11.60	9.30	----
DEC Existing Condition Model	DEC's existing model, includes all Post2002 BMPs	-1.71	0.00	1/31/2014
WCA Revised Existing Condition Model	Revised subwatersheds and BMPs	-2.84	-4.35	5/16/2014
WCA Revised Existing Condition Model	Revised subwatersheds and BMPs	-2.25	-4.35	9/9/2014
WCA Revised Existing Condition Model	Added #1-0818 BMPs	-2.37	-4.35	11/14/2014
WCA Revised Existing Condition Model	Base model change to 2-0261a and drainage area.	-2.54	-4.35	12/9/2014
Percent of Original Target Managed (w/ Existing 12/9/14 model)		8%	0%	----
Percent of Modified Target Managed (w/ Existing 12/9/14 model)		22%	0%	----
Credit1 Model	Initial Proposed BMP scenario	-16.15	0.00	9/10/2014
Percent of Original Target Managed (with Credit1 run)		49%	0%	----
Percent of Modified Target Managed (with Credit1 run)		139%	0%	----
Credit2 Model	Additional BMPs added to Credit1 model scenario	-21.71	4.35	11/14/2014
Percent of Original Target Managed (with Credit2 run)		65%	33%	----
Percent of ModifiedTarget Managed (with Credit2 run)		187%	47%	----
Credit3_GSI Model (Proposed FRP Scenario)	Proposed FRP Scenario (Add GSI Planters to Credit2 model scenario)	-22.56	4.35	12/9/2014
Percent of Original Target Managed (with Credit3_GSI run)		68%	33%	----
Percent of ModifiedTarget Managed (with Credit3_GSI run)		194%	47%	----
Credit 3 Model	Add 4 additional BMPs to account for TMDL Future Growth of 50 acres	-28.71	8.70	12/11/2014
Percent of Original Target Managed (with Credit3 run)		86%	66%	----
Percent of ModifiedTarget Managed (with Credit3 run)		248%	94%	----

Table A-3-2: BMP List Sorted by BMPDSS Model Run

ID	Proposed BMP ID	MS4	Ownership where BMP is located	BMP Type	Permit #	Model Scenario BMP was first added
2	Keari Lane	South Burlington	City of S. Burlington	Infiltration Gallery	Expired #1-0202 and 2-0120	Credit1
3	Horticulture Farm Basin	UVM	UVM	Bioretention	1-1155 Pond A and B Drainage	Credit1
4	Deerfield Dr. Dug Pond	UVM	UVM	Detention	1-1155 Pond A and B Drainage	Credit1
6	Laurel Hill Development	UVM	UVM	Culvert Retrofit	NP	Credit1
16	1-1404b Irish Farm Condos Pond B,C	South Burlington	HOA	Pond Upgrade	1-1404 Pond B Upgrade	Credit1
1	BBTS Combined	South Burlington/VTRANS	Private Owner	BBTS Wetland	5625-9010,, 2-0180, 2-0153	Credit2
5	Spear St.	South Burlington	Private Owner	Detention Basin	2061	Credit2
7	Holiday Inn Parking Lot	South Burlington	Developer- Pizzagalli	Detention Basin	6297-9030	Credit2
8	Allen Rd.	South Burlington	City ROW	Detention Basin	NP	Credit2
9	1690 Shelburne Rd./ Route 7	South Burlington	VTRANS/ Developer- Pizzagalli	Detention Basin	5625-9010	Credit2
17	1-1155a Pinnacle at spear	South Burlington	Private Owner	Pond Upgrade	1-1155	Credit2
18	1-1155b Pinnacle at spear	South Burlington	Private Owner	Pond Upgrade	1-1155	Credit2
10	Windsor Ct-1	South Burlington	City ROW	ROW Infiltration	2-0261_b	Credit3_GSI
11	Brownell Way-3	South Burlington	City ROW	ROW Planter	2-0261_b	Credit3_GSI
12	Brownell Way 1-2	South Burlington	City ROW	ROW Infiltration	2-0261_b	Credit3_GSI
13	Deerfield Dr. 1-3	South Burlington	City ROW	ROW Infiltration	2-0261_d	Credit3_GSI
14	Deerfield Dr.-4-6	South Burlington	City ROW	ROW Planter	2-0261_d	Credit3_GSI
15	Whatley Rd 1-5	South Burlington	City ROW	ROW Planter	2-0261_d	Credit3_GSI
Additional BMPs in Full Built-out Scenario for Compliance with Original TMDL target (50 acres of Non-Jurisdictional Growth)						
19	1-1220 Allen Rd Community Care	South Burlington	Private	Infiltration Basin	1-1220	Credit3
20	1-0665 Pillsbury Manor	South Burlington	Private	Underground Detention Basin	1-0665	Credit3
21	Overlook Dr.	South Burlington	Private/UVM	Detention Basin	NP	Credit3
22	Option 7 Pond	South Burlington	UVM	Pond	NP	Credit3

APPENDIX 4

MAP OF BEST MANAGEMENT PRACTICES INCLUDED IN THE BARTLETT BROOK FLOW RESTORATION PLAN

APPENDIX 5

TABLE A-5-1: BMP RANKING CRITERIA KEY

TABLE A-5-2: SCORING KEY

Table A-5-1: BMP Ranking Criteria Key

Category	ID	Criteria	Technical Description	Description
Cost/Operations	A	Project Cost	The project costs were grouped into categories from >\$50,000 to \$1,000,000 based on the range of projects proposed. Cost estimates were developed using the latest unit costs from VTrans as well as local experience. More expensive	Project Costs include additional engineering, permitting, and construction. Transportation and utility conflicts, as well as overall constructability is also reflected in the cost.
Project Design Metrics	B	Impervious Acres Managed (ac)	Natural groupings within the range of impervious managed for the proposed projects were identified. More impervious managed receives a higher score.	The more impervious managed by a project, the higher the potential pollutant reduction. Additionally, the goal of the FRP is to manage existing impervious surfaces.
	C	Channel Protection Volume (CPv) Mitigated, (i.e.. 1-year Storm)	Groupings within the range of CPv volume storage were identified. The largest grouping receives the highest score. The CPv was estimated in HydroCAD, using local rainfall data.	The Channel Protection Volume (CPv) is the volume of stormwater runoff generated from the 1-year design storm (1.98" in Burlington). A BMP which provides CPv storage was determined to reduce the High-flow (Q0.3%), which is the flow rate exceeded 0.3% of the time (output from the State's BMPDSS model). Mitigating the CPv reduces channel erosion and excessive
	D	Volume Infiltrated (ac-ft)	Natural groupings within the range of volumes infiltrated for the BMPs were identified to which relative points were be assigned. The largest volume infiltrated was assigned the highest score. Volumes were calculated in HydroCAD.	The Volume Infiltrated indicates the amount of stormwater runoff that is infiltrated into the groundwater, and provides baseflow for the stream. The TMDL flow targets include a low-flow target, which is addressed by an infiltration-based BMP.
Project Implementation	E	Permitability	Permitability is simplified into two categories to reflect the common scenarios in permitting, as 1) minimal permitting, versus 2) Complex permitting issues. An itemized list of permits was included to inform the ranking, but was not used in the scoring.	Permitability is a measure of the expected level of effort to permit the project, based on knowledge that each type of permit takes varying amounts of time. Some common permits include Stormwater Construction, Local Zoning, Act 250 amendments, VTRANS ROW, etc.
	F	Land Availability	Public land is preferred, followed by regulated private land, and private land where the owners are known to be open to participate. Private land, in which participation of the owner is unknown is lower priority.	Land availability is critical for BMPs requiring open space for detention and access for the City. Properties owned by the City are ranked the highest, followed by privately owned land that has an expired permit, which provides leverage for owner participation.
Other Project Benefits	G	Flood Mitigation	Flood mitigation is categorized by the scale of the impact.	Flood mitigation is categorized by the scale of the impact. A neighborhood flooding issue is weighed more heavily than a localized drainage issue.
	H	TMDL Flow Target Addressed (Q03, Q95)	More weight is on BMPs that address both TMDL targets- the high-flow (Q0.3%) and low-flow targets (Q95%). The high-flow target is addressed by detention BMPs which storage the CP volume.	The goal of the FRP is to implement projects which address the TMDL flow targets. The high-flow target is measured as a reduction in the stream flow rate exceeded 0.3% of the time, while the low-flow target is an increase in the stream flow rate exceeded 95% of the time (baseflow). Projects which address both targets through storage or infiltration of the 1-year design storm are weighted the highest, followed by projects which address just the high-flow. Projects which do not address the full 1-year storm volume are weighted the lowest.
	I	Lake Champlain Phosphorus TMDL	Yes or no whether the proposed practice will provide benefit toward the Lake Champlain Phosphorus TMDL. This will be determined once the TMDL compliance metrics are released.	The Lake Champlain Phosphorus TMDL has been developed in the effort to reduce nutrient loading and consequential toxic algal blooms in Lake Champlain. The TMDL will require stormwater BMPs to meet a certain level of Total Phosphorus reduction. Each BMP will be evaluated against the TMDL compliance metrics, and scored yes or no if the project meets the TMDL standards.
	J	Other Project Benefits/Constraints	This criteria is to account for indirect project benefits like infrastructure improvements (e.g. aging culvert replacement, wetlands enhancement, and if it addresses an expired permit), or potential constraints (e.g. utility issues encountered during construction).	This criteria is to account for indirect project benefits like infrastructure improvements, community benefits, habitat creation, etc., as well as things that might constrain the project such as the potential of encountering utilities during construction.

Table A-5-2: Scoring Key

Category	ID	Criteria	Quality	Score
Cost/Operations	A	Relative Project Cost	\$1.00 - \$24,999	4
			\$25,000 - \$49,999	3
			\$49,999 - \$99,999	2
			\$100,000 - \$199,999	1
			\$200,000 - \$499,999	0
			\$500,000 +	-1
Project Design Metrics	B	Impervious Acres Managed (ac)	>10 acres	6
			>5-10 acres	5
			>4-5 acres	4
			>2-4 acres	3
			>1-2 acres	2
			< 1 acre	1
			0 acres	0
	C	Channel Protection Volume (CPv) Mitigated, (ie. 1-year Storm)	0.6-1.0 ac-ft	5
			0.4-0.6 ac-ft	4
			0.2-0.4 ac-ft	3
			0.05-0.2 ac-ft	2
			>0-0.05 ac-ft	1
Project Implementation	E	Permitability	Minimal Issues/Concerns or no permits	2
			Complex issues/Potential permit denial	0
	F	Land Availability	MS4 owned	4
			Non MS4 owned regulated (expire permit)	3
			Non MS4 owned/Participatory Owner	2
			Unknown	0
			Not MS4 owned/Non participatory owner	-2
	G	Flood Mitigation (Is existing flooding issue mitigated by project?)	Neighborhood Wide Flooding Issue	3
			Infrastructure damage (e.g. Wet Basement)	2
			Nuisance Issue (ie. ponding, puddles, etc).	1
			None	0
Other Project Benefits	H	TMDL Flow Target Addressed (Q03, Q95)	High and Low Flow Targets	3
			High Flow Target	2
			No target addressed in BMPDSS (just WQ treatment)	1
	I	Lake Champlain Phosphorus TMDL	Addressed TMDL	1
			Does not address TMDL	0
	J	Other Project Benefits	Infrastructure Improvement (e.g. Culvert Replacement)	1
			Educational/Functional Benefit	1
			Recreational Benefit	1
			Natural Habitat Creation/Protection	1
			Outfall Erosion Control	1
			Utility Issues/Uncertainty	-1

APPENDIX 6

BARTLETT BROOK WATERSHED BMP DESIGN AND CONSTRUCTION SCHEDULE

Bartlett Brook Flow Restoration Plan
Bartlett Brook Watershed BMP Project Implementation Schedule

Project ID	Project Name	Expired Permit	MS4	BMP Type	BMP Description	Implementation Year	Project Cost (Rounded to Nearest \$1,000)	Project Cost with Inflation (Rounded to Nearest \$1,000)
BB0003	Bartlett Brook Central Stormwater Improvement Project (BBCSIP)	1-0202; 2-0120	South Burlington	IG/ GW	Infiltration Gallery/Gravel Wetland at confluence of two large outfalls. Outfalls currently have significant erosion issues. Land acquisition is not required for the project.	2017	\$ 1,000,000	\$ 1,093,000
BB0014	Pinnacle at Spear Pond A	1-1155	South Burlington	DP	The outlet structure on Pond a (North lot) is proposed for retrofit, including the removal of the existing 12" culvert, replaced with a 3" low-flow orifice.	2018	\$ 20,000	\$ 23,000
BB0015	Pinnacle at Spear Pond B	1-1155	South Burlington	DP	The outlet structure on Pond b (along Spear St) is proposed for retrofit including the addition of two low-flow orifices, 1" at 371' and a 2" at 373.5'. The retrofits will provide 0.139 ac-ft of CPv storage.	2018	\$ 27,000	\$ 30,000
BB0004	BBSTS Expansion	2-0180; 2-0153; 1-0734	South Burlington	DP	The proposed expansion of the BBTS system would be to route additional area to system via a new stormline connection on Route 7 from a portion of Route 7 and Harborview Dr. The expansion would involve adding a new forebay for the additional connection in front of the Oil N Go property, as well as expanding the southeast portion of the wetland. The existing access road would also be repositioned.	2019	\$ 378,000	\$ 438,000
BB0001	1690 Shelburne Road	No Permit	VTrans	UD	Detain unmanaged portion of Route 7 in underground detention chamber.	2019	\$ 199,000	\$ 231,000
BB0010	Horticulture Farm Bioretention	No Permit	UVM	Bio	The proposed site was identified as an excellent candidate to improve the overall aesthetics of the walking path, while also providing significant stormwater management. The project would involve a retrofit of the swale into a 0.81 ac-ft bioretention basin. A berm in the center of the basin would provide an extended flow path to improve water quality treatment.	2020	\$ 268,000	\$ 320,000
BB0011	Horticulture Farm Detention Pond	1-1155	UVM	DP	BMP is located on the UVM Horticulture Farm property, for which irrigation is an everpresent need. The 10-year storm (Qp10) overflow from the Horticulture Farm basin would be routed to the dug pond, providing a store of usable water on-site and Qp10 control for the basin.	2020	\$ 185,000	\$ 221,000
BB0007	Deerfield Drive 1	2-0261	South Burlington	IB	System of Infiltration Trenches in ROW.	2021	\$ 141,000	\$ 173,000
BB0012	Irish Farm Condos Pond B	1-1404	South Burlington	GW	Upgrade existing pond to gravel wetland STP, with more storage. Route additional 5.47 acres to Pond B.	2021	\$ 247,000	\$ 304,000
BB0017	Whatley Road	2-0261	South Burlington	Bio	System of Filter strips with storage in ROW.	2021	\$ 189,000	\$ 232,000
BB0005	Brownell Way	2-0261	South Burlington	IB	System of Infiltration Trenches in ROW.	2021	\$ 91,000	\$ 112,000
BB0018	Windsor Court	2-0261	South Burlington	IB	System of Infiltration Trenches in ROW.	2021	\$ 27,000	\$ 33,000
BB0008	Deerfield Drive 2	2-0261	South Burlington	Bio	System of Filter strips with storage in ROW.	2021	\$ 116,000	\$ 143,000
BB0006	Brownell Way-3	2-0261	South Burlington	Bio	System of Filter strips with storage in ROW.	2021	\$ 25,000	\$ 31,000

BB0009	Holiday Inn Parking Lot	6297-9030	South Burlington	UD	Opportunity for an underground infiltration gallery in the open space to mitigate runoff from the Holiday Inn Parking lot. Also potential to route drainage from Staybridge Hotel, which is currently routed to a detention pond not meeting the VT CPv standard. Option to provide an offset project for new development.	2023	\$ 189,000	\$ 247,000
BB0013	Laurel Hill Detention Pond at Horticulture Farm	No Permit	South Burlington	DP	An existing 32" culvert, located on the UVM horticulture farm property, just South of the Laurel Hill Neighborhood was identified as an opportunity for retrofit to provide more storage. The proposed retrofit would involve installing a headwall at the culvert and outlet control structure to increase the CPv storage capacity while still safely passing the larger storm events.	2024	\$ 167,000	\$ 224,000
BB0016	Underwood Stormwater Pond	No Permit	South Burlington	DP	The confluence of the existing stormline along Spear St, just South of Nowland Farm Rd. has been the source of flooding during large storm events. The proposed project would involve a retrofit of the existing roadside swale into a detention basin, designed to provide CPv (1-year) for a 44.3 acre area in the upper Bartlett Brook watershed.	2025	\$ 222,000	\$ 307,000
BB0002	Allen Road	Offset Permit	South Burlington	DP	The Allen Rd detention basin was designed as a retrofit of an existing swale in the ROW. The basin would mitigate runoff from a 6.38 acres drainage area, providing 0.07 ac-ft of volume storage. The site would require a new culvert under the roadway in order to route additional runoff to the swale.	2028	\$ 69,000	\$ 104,000

APPENDIX 7
ITEMIZED COST ESTIMATES

CITY OF SOUTH BURLINGTON
BARTLETT BROOK FRP

Bartlett Bay Treatment System Opinion of Probable Construction Cost (30% Design)
As of December 4, 2014

Item #	Vtrans Item	RS Means Item	Description	Estimated Quantity	Unit	Unit Cost	Total Cost (ENR 9900) ⁽¹⁾	Total Cost (ENR 10000) ⁽²⁾
I. CONSTRUCTION COST								
1	204.20		Trench Excavation of Earth	1,560	CY	\$ 12.00	\$ 18,696.00	\$ 18,884.85
2	204.22		Trench Excavation of Earth, Exploratory	100	CY	\$ 65.00	\$ 6,500.00	\$ 6,565.66
3	204.25		Structure Excavation	90	CY	\$ 20.00	\$ 1,800.00	\$ 1,818.18
4	204.30		Granular Backfill for Structures	60	CY	\$ 34.00	\$ 2,040.00	\$ 2,060.61
5			Bituminous Pavement	280	SY	\$ 74.55	\$ 20,277.29	\$ 20,482.11
6	601.09		CPEP (18")	1,060	LF	\$ 50.00	\$ 52,850.00	\$ 53,383.84
7	601.09		CPEP (15")	170	LF	\$ 47.00	\$ 7,990.00	\$ 8,070.71
8			3/4" Crushed Stone for Pipe	330	CY	\$ 30.00	\$ 9,900.00	\$ 10,000.00
9	604.2		Precast Reinforced Concrete Catch Basin with Frame and Grate	35	VF	\$ 340.00	\$ 10,880.00	\$ 10,989.90
10			Retrofit Existing Catch Basin	2	EA	\$ 265.00	\$ 530.00	\$ 535.35
11	635.11		Mobilization/Demobilization	1	LS	\$ 18,000.00	\$ 18,000.00	\$ 18,181.82
12	649.51		Geotextile for Silt Fence	400	SY	\$ 5.00	\$ 2,000.00	\$ 2,020.20
13	651.15		Seed	10	LB	\$ 10.00	\$ 100.00	\$ 101.01
14	651.28		Hydraulic Mulch	50	Gal	\$ 12.00	\$ 600.00	\$ 606.06
15	651.35		Topsoil	500	CY	\$ 40.00	\$ 20,000.00	\$ 20,202.02
16	652.10		Erosion Prevention Sediment Control Plan	1	LS	\$ 1,500.00	\$ 1,500.00	\$ 1,515.15
17	652.20		Monitoring Erosion Prevention Sediment Control Plan	40	HR	\$ 60.00	\$ 2,400.00	\$ 2,424.24
18	652.30		Maintenance of EPSCP	1	LS	\$ 3,500.00	\$ 3,500.00	\$ 3,535.35
19	653.35		Vehicle Tracking Pad	150	CY	\$ 42.00	\$ 6,300.00	\$ 6,363.64
20	653.55		Project Demarcation Fence	2,000	LF	\$ 2.00	\$ 4,000.00	\$ 4,040.40
21			Forebay (All Inclusive)	1	LS	\$ 28,676.00	\$ 28,676.00	\$ 28,965.66
22			Swale (All Inclusive)	380	LF	\$ 11.96	\$ 4,545.00	\$ 4,590.91
23			Basin Expansion (All Inclusive)	1	LS	\$ 31,400.33	\$ 31,400.33	\$ 31,717.51
24			Bonds (2.0%)	1	LS	\$ 5,089.69	\$ 5,089.69	\$ 5,141.10
SUBTOTAL CONSTRUCTION:							\$ 262,196.28	
USE:							\$ 270,000.00	
II. CONSTRUCTION CONTINGENCY								
1			Construction Contingency (15%)	1		\$ 40,500.00		\$ 40,500.00
SUBTOTAL CONSTRUCTION CONTINGENCY:							\$ 40,500.00	
III. FINAL DESIGN ENGINEERING⁽³⁾								
1			Final Design and Permitting (excluding geotechnical)	1		\$ 20,580.00		\$ 20,580.00
2			Geotechnical	0		\$ 2,700.00		\$ -
SUBTOTAL FINAL DESIGN ENGINEERING:							\$ 20,580.00	
IV. CONSTRUCTION PHASE ENGINEERING⁽³⁾								
1			Construction Phase Engineering	1		\$ 37,730.00		\$ 37,730.00
SUBTOTAL CONSTRUCTION PHASE ENGINEERING:							\$ 37,730.00	
V. OTHER COSTS								
1			Administrative	1		\$ 1,350.00		\$ 1,350.00
2			Easement Assistance	1		\$ 4,050.00		\$ 4,050.00
3			Land Acquisition		Acre	\$ 120,000.00		\$ -
4			Legal	1		\$ 4,050.00		\$ 4,050.00
5			Bond Vote Assistance			\$ 1,350.000		\$ -
6			Short Term Interest	0		\$ 6,750.000		\$ -
SUBTOTAL OTHER COSTS:							\$ 9,450.00	
TOTAL PROJECT COST:							\$ 378,260.00	
USE:							\$ 380,000.00	

Notes:

1. ENR 9900 = November 2014
2. ENR 10,000 = June 2015
3. Engineering costs for Final Design and Construction are based on the VT DEC Facilities Engineering Fee Curve Allowance

CITY OF SOUTH BURLINGTON
BARTLETT BROOK FRP

Keari Lane Opinion of Probable Construction Cost (30% Design)
As of November 3, 2014

Item #		Vtrans Item	RS Means Item	Description	Estimated Quantity	Unit	Unit Cost	Total Cost (ENR 9900) ⁽¹⁾	Total Cost (ENR 10000) ⁽²⁾
I. CONSTRUCTION COST									
1		204.20		Trench Excavation of Earth	420	CY	\$ 12.00	\$ 5,016.00	\$ 5,066.67
2		204.22		Trench Excavation of Earth, Exploratory	100	CY	\$ 65.00	\$ 6,500.00	\$ 6,565.66
3		204.25		Structure Excavation	90	CY	\$ 20.00	\$ 1,640.00	\$ 1,656.57
4		204.30		Granular Backfill for Structures	40	CY	\$ 34.00	\$ 1,258.00	\$ 1,270.71
5				Bituminous Pavement	1,330	SY	\$ 74.55	\$ 99,150.00	\$ 100,151.52
6		601.09		CPEP (24")	1,200	LF	\$ 52.00	\$ 62,244.00	\$ 62,872.73
7				3/4" Crushed Stone for Pipe	330	CY	\$ 30.00	\$ 9,780.00	\$ 9,878.79
8		604.21		Precast Reinforced Concrete Catch Basin with Cast Iron Cover	30	VF	\$ 340.00	\$ 8,160.00	\$ 8,242.42
9				Retrofit Existing Catch Basin	2	EA	\$ 265.00	\$ 530.00	\$ 535.35
10		635.11		Mobilization/Demobilization	10	LS	\$ 25,000.00	\$ 25,000.00	\$ 25,252.53
11		649.51		Geotextile for Silt Fence	100	SY	\$ 5.00	\$ 500.00	\$ 505.05
12		651.15		Seed	10	LB	\$ 10.00	\$ 100.00	\$ 101.01
13		651.28		Hydraulic Mulch	50	Gal	\$ 12.00	\$ 600.00	\$ 606.06
14		651.35		Topsoil	500	CY	\$ 40.00	\$ 20,000.00	\$ 20,202.02
15		652.10		Erosion Prevention Sediment Control Plan	1	LS	\$ 1,500.00	\$ 1,500.00	\$ 1,515.15
16		652.20		Monitoring Erosion Prevention Sediment Control Plan	60	HR	\$ 60.00	\$ 3,600.00	\$ 3,636.36
17		652.30		Maintenance of EPSCP	1	LS	\$ 4,000.00	\$ 4,000.00	\$ 4,040.40
18		653.20		Temporary Erosion Matting	1,000	SY	\$ 7.50	\$ 7,500.00	\$ 7,575.76
19		653.35		Vehicle Tracking Pad	20	CY	\$ 42.00	\$ 630.00	\$ 636.36
20		653.55		Project Demarcation Fence	200	LF	\$ 2.00	\$ 400.00	\$ 404.04
21				Pre-treatment Downstream Defender	1	LS	\$ 22,249.84	\$ 22,249.84	\$ 22,474.59
22				Manifold (All Inclusive)	260	LF	\$ 67.58	\$ 17,029.00	\$ 17,201.01
23				StormTech Chambers (All Inclusive)	25,600	CF	\$ 11.17	\$ 285,776.55	\$ 288,663.18
24				Bonds (2.0%)	1	LS	\$ 11,663.27	\$ 11,663.27	\$ 11,781.08
SUBTOTAL CONSTRUCTION: \$ 600,835.01								USE: \$ 610,000.00	
II. CONSTRUCTION CONTINGENCY									
1				Construction Contingency (15%)	1		\$ 91,500.00		\$ 91,500.00
SUBTOTAL CONSTRUCTION CONTINGENCY: \$ 91,500.00									
III. FINAL DESIGN ENGINEERING ⁽³⁾									
1				Final Design and Permitting (excluding geotechnical)	1		\$ 44,040.00		\$ 44,040.00
2				Geotechnical	1		\$ 6,100.00		\$ 6,100.00
SUBTOTAL FINAL DESIGN ENGINEERING: \$ 50,140.00									
IV. CONSTRUCTION PHASE ENGINEERING ⁽³⁾									
1				Construction Phase Engineering	1		\$ 80,740.00		\$ 80,740.00
SUBTOTAL CONSTRUCTION PHASE ENGINEERING: \$ 80,740.00									
V. OTHER COSTS									
1				Administrative	1		\$ 3,050.00		\$ 3,050.00
2				Easement Assistance	1		\$ 9,150.00		\$ 9,150.00
3				Land Acquisition	0	Acre	\$ 120,000.00		\$ -
4				Legal	1		\$ 9,150.00		\$ 9,150.00
5				Bond Vote Assistance			\$ 3,050.000		\$ -
6				Short Term Interest			\$ 15,250.000		\$ -
SUBTOTAL OTHER COSTS: \$ 21,350.00									
TOTAL PROJECT COST: \$ 853,730.00								USE: \$ 860,000.00	

Notes:

1. ENR 9900 = November 2014
2. ENR 10,000 = June 2015
3. Engineering costs for Final Design and Construction are based on the VT DEC Facilities Engineering Fee Curve Allowance

CITY OF SOUTH BURLINGTON
BARTLETT BROOK FRP

Irish Farm Opinion of Probable Construction Cost (30% Design)
As of December 4, 2014

Item #		Vtrans Item	RS Means Item	Description	Estimated Quantity	Unit	Unit Cost	Total Cost (ENR 9900) ⁽¹⁾	Total Cost (ENR 10000) ⁽²⁾
I. CONSTRUCTION COST									
1				Gravel Wetland (Existing Upper Pond Expansion)	1	LS	\$ 71,977.60	\$ 71,977.60	\$ 72,704.65
2				Lower Pond	1	LS	\$ 10,020.00	\$ 10,020.00	\$ 10,121.21
3		635.11		Mobilization/Demobilization	1	LS	\$ 6,000.00	\$ 6,000.00	\$ 6,060.61
4		652.10		Erosion Prevention Sediment Control Plan	1	LS	\$ 1,500.00	\$ 1,500.00	\$ 1,515.15
5		652.20		Monitoring Erosion Prevention Sediment Control Plan	20	HR	\$ 60.00	\$ 1,200.00	\$ 1,212.12
6		652.30		Maintenance of EPSCP	1	LS	\$ 2,500.00	\$ 2,500.00	\$ 2,525.25
7		653.35		Vehicle Tracking Pad	150	CY	\$ 42.00	\$ 6,300.00	\$ 6,363.64
8		653.55		Project Demarcation Fence	1,000	LF	\$ 2.00	\$ 2,000.00	\$ 2,020.20
9				Bonds (2.0%)	1	LS	\$ 2,029.95	\$ 2,029.95	\$ 2,050.46
								SUBTOTAL CONSTRUCTION:	\$ 104,573.29
								USE:	\$ 110,000.00
II. CONSTRUCTION CONTINGENCY									
1				Construction Contingency (15%)	1		\$ 16,500.00		\$ 16,500.00
								SUBTOTAL CONSTRUCTION CONTINGENCY:	\$ 16,500.00
III. FINAL DESIGN ENGINEERING ⁽³⁾									
1				Final Design and Permitting (excluding geotechnical)	1		\$ 9,540.00		\$ 9,540.00
2				Geotechnical	0		\$ 1,100.00		\$ -
								SUBTOTAL FINAL DESIGN ENGINEERING:	\$ 9,540.00
IV. CONSTRUCTION PHASE ENGINEERING ⁽³⁾									
1				Construction Phase Engineering	1		\$ 17,490.00		\$ 17,490.00
								SUBTOTAL CONSTRUCTION PHASE ENGINEERING:	\$ 17,490.00
V. OTHER COSTS									
1				Administrative	1		\$ 550.00		\$ 550.00
2				Easement Assistance	1		\$ 1,650.00		\$ 1,650.00
3				Land Acquisition	0.75	Acre	\$ 120,000.00		\$ 90,000.00
4				Legal	1		\$ 1,650.00		\$ 1,650.00
5				Bond Vote Assistance			\$ 550.000		\$ -
6				Short Term Interest			\$ 2,750.000		\$ -
								SUBTOTAL OTHER COSTS:	\$ 93,850.00
								TOTAL PROJECT COST:	\$ 247,380.00
								USE:	\$ 250,000.00

Notes:

1. ENR 9900 = November 2014
2. ENR 10,000 = June 2015
3. Engineering costs for Final Design and Construction are based on the VT DEC Facilities Engineering Fee Curve Allowance

CITY OF SOUTH BURLINGTON
BARTLETT BROOK FRP

UVM Horticulture Farm Option 1 System Opinion of Probable Construction Cost (30% Design)
As of December 4, 2014

Item #	Vtrans Item	RS Means Item	Description	Estimated Quantity	Unit	Unit Cost	Total Cost (ENR 9900) ⁽¹⁾	Total Cost (ENR 10000) ⁽²⁾
I. CONSTRUCTION COST								
1			Recreational Path Basin	1	LS	\$ 144,574.00	\$ 144,574.00	\$ 146,034.34
2	635.11		Mobilization/Demobilization	1	LS	\$ 12,000.00	\$ 12,000.00	\$ 12,121.21
3	652.10		Erosion Prevention Sediment Control Plan	1	LS	\$ 1,500.00	\$ 1,500.00	\$ 1,515.15
4	652.20		Monitoring Erosion Prevention Sediment Control Plan	60	HR	\$ 60.00	\$ 3,600.00	\$ 3,636.36
5	652.30		Maintenance of EPSCP	1	LS	\$ 2,500.00	\$ 2,500.00	\$ 2,525.25
6	653.35		Vehicle Tracking Pad	150	CY	\$ 42.00	\$ 6,300.00	\$ 6,363.64
7	649.51		Geotextile for Silt Fence (Double Row)	500	SY	\$ 5.00	\$ 2,500.00	\$ 2,525.25
8	653.55		Project Demarcation Fence	1,000	LF	\$ 2.00	\$ 2,000.00	\$ 2,020.20
9			Bonds (2.0%)	1	LS	\$ 3,499.48	\$ 3,499.48	\$ 3,534.83
							SUBTOTAL CONSTRUCTION: \$ 180,276.24	
							USE: \$ 190,000.00	
II. CONSTRUCTION CONTINGENCY								
1			Construction Contingency (15%)	1		\$ 28,500.00		\$ 28,500.00
							SUBTOTAL CONSTRUCTION CONTINGENCY: \$ 28,500.00	
III. FINAL DESIGN ENGINEERING ⁽³⁾								
1			Final Design and Permitting (excluding geotechnical)	1		\$ 15,060.00		\$ 15,060.00
2			Geotechnical	0		\$ 1,900.00		\$ -
							SUBTOTAL FINAL DESIGN ENGINEERING: \$ 15,060.00	
IV. CONSTRUCTION PHASE ENGINEERING ⁽³⁾								
1			Construction Phase Engineering	1		\$ 27,610.00		\$ 27,610.00
							SUBTOTAL CONSTRUCTION PHASE ENGINEERING: \$ 27,610.00	
V. OTHER COSTS								
1			Administrative	1		\$ 950.00		\$ 950.00
2			Easement Assistance	1		\$ 2,850.00		\$ 2,850.00
3			Land Acquisition	0	Acre	\$ 120,000.00		\$ -
4			Legal	1		\$ 2,850.00		\$ 2,850.00
5			Bond Vote Assistance			\$ 950.000		\$ -
6			Short Term Interest			\$ 4,750.000		\$ -
							SUBTOTAL OTHER COSTS: \$ 6,650.00	
							TOTAL PROJECT COST: \$ 267,820.00	
							USE: \$ 270,000.00	

Notes:

1. ENR 9900 = November 2014
2. ENR 10,000 = June 2015
3. Engineering costs for Final Design and Construction are based on the VT DEC Facilities Engineering Fee Curve Allowance

CITY OF SOUTH BURLINGTON
BARTLETT BROOK FRP

Deerfield Dr-UVM Horticulture Farm Option 2 System Opinion of Probable Construction Cost (30% Design)
As of December 4, 2014

Item #		Vtrans Item	RS Means Item	Description	Estimated Quantity	Unit	Unit Cost	Total Cost (ENR 9900) ⁽¹⁾	Total Cost (ENR 10000) ⁽²⁾
I. CONSTRUCTION COST									
1				Pond Option 2 (Middle Pond)	1	LS	\$ 100,299.00	\$ 100,299.00	\$ 101,312.12
2		635.11		Mobilization/Demobilization	1	LS	\$ 7,000.00	\$ 7,000.00	\$ 7,070.71
3		652.10		Erosion Prevention Sediment Control Plan	1	LS	\$ 1,500.00	\$ 1,500.00	\$ 1,515.15
4		652.20		Monitoring Erosion Prevention Sediment Control Plan	40	HR	\$ 60.00	\$ 2,400.00	\$ 2,424.24
5		652.30		Maintenance of EPSCP	1	LS	\$ 2,000.00	\$ 2,000.00	\$ 2,020.20
6		653.35		Vehicle Tracking Pad	150	CY	\$ 42.00	\$ 6,300.00	\$ 6,363.64
7		653.55		Project Demarcation Fence	500	LF	\$ 3.50	\$ 1,750.00	\$ 1,767.68
8				Bonds (2.0%)	1	LS	\$ 2,424.98	\$ 2,424.98	\$ 2,449.47
SUBTOTAL CONSTRUCTION:								\$ 124,923.21	
USE:								\$ 130,000.00	
II. CONSTRUCTION CONTINGENCY									
1				Construction Contingency (15%)	1		\$ 19,500.00		\$ 19,500.00
SUBTOTAL CONSTRUCTION CONTINGENCY:								\$ 19,500.00	
III. FINAL DESIGN ENGINEERING ⁽³⁾									
1				Final Design and Permitting (excluding geotechnical)	1		\$ 10,920.00		\$ 10,920.00
2				Geotechnical	0		\$ 1,300.00		\$ -
SUBTOTAL FINAL DESIGN ENGINEERING:								\$ 10,920.00	
IV. CONSTRUCTION PHASE ENGINEERING ⁽³⁾									
1				Construction Phase Engineering	1		\$ 20,020.00		\$ 20,020.00
SUBTOTAL CONSTRUCTION PHASE ENGINEERING:								\$ 20,020.00	
V. OTHER COSTS									
1				Administrative	1		\$ 650.00		\$ 650.00
2				Easement Assistance	1		\$ 1,950.00		\$ 1,950.00
3				Land Acquisition	0	Acre	\$ 120,000.00		\$ -
4				Legal	1		\$ 1,950.00		\$ 1,950.00
5				Bond Vote Assistance			\$ 650.000		\$ -
6				Short Term Interest			\$ 3,250.000		\$ -
SUBTOTAL OTHER COSTS:								\$ 4,550.00	
TOTAL PROJECT COST:								\$ 184,990.00	
USE:								\$ 190,000.00	

Notes:

1. ENR 9900 = November 2014

2. ENR 10,000 = June 2015

3. Engineering costs for Final Design and Construction are based on the VT DEC Facilities Engineering Fee Curve Allowance

APPENDIX 8

HORSLEY WITTEN GROUP MEMORANDUM
DATED JANUARY 9, 2014



MEMORANDUM

DATE: January 9, 2014

TO: Dan Albrecht; Megan Moir; Tom DiPietro; Jennifer Callahan; Bill Nedde, Linda Seavey, and Lani Ravin

FROM: Horsley Witten Group, Inc.

RE: Centennial Brook Watershed: Flow Restoration VTBMPDSS Modeling Analysis and BMP Supporting Information

This memorandum describes the basic approach used to model potential stormwater retrofits for the Centennial Brook Flow Restoration Plan (FRP) using the VT BMPDSS model. Modeling efforts have proven that it is difficult to meet the **63.0%** high flow reduction target required by the Centennial Brook TMDL. In fact, the percent flow reduction achieved under the proposed restoration scenario is **44.2%**. This reduction reflects management of 90% of the watershed impervious cover using all retrofits identified in the field and vetted with the MS4s. Under this scenario, UVM's existing Main St. and North Campus ponds would be modified from their current configuration to improve performance while maintaining 12-hr detention times and storage capacity for future development activities (only the proposed Colchester Ave. watershed expansion is incorporated into the model at this time).

Table 1 summarizes high flow reduction targets established by the TMDL, a revised target based on an analysis of future impervious cover, and the percent reduction achieved under the currently modeled VTBMPDSS restoration scenario. Figures 1-3 show impervious cover and drainage area maps for the proposed restoration scenario, including a zoom in of the proposed Colchester Avenue expansion.

Table 1. Summary of Percent Flow Reductions Achieved

Description		% High Flow Reduction	Managed IA (acres)	Planning Level Cost ⁵
TMDL Reduction Targets	TMDL baseline with no agriculture.	49.9	--	--
	TMDL with no agriculture and 40 acres future, unmanaged impervious cover.	63.0	--	--
	TMDL with no agriculture and revised 5 acres of future, unmanaged impervious cover. ¹	51.5 ²	--	--
Current Conditions	All existing BMPs (revised ANR BMPDSS Credit Model)	14.8	106.1 ³	--
Proposed Flow Restoration Scenario	All primary and secondary retrofits; existing UVM facilities meeting 12-hr detention criteria and maintaining future use allocations; Colchester Ave watershed expansion included. ⁴	44.2	243.7	\$9,740,000

¹ Based on 2013 analysis conducted by CCRPC for Burlington and South Burlington.

² 51.5% = 49.9% baseline target + 5/40 acres future IA * 13.1% reduction target associated with future IA

³ IA managed by post-2002 BMPs, which does not include Main Street and Queensbury ponds (based on most recently available GIS)

⁴ One surface detention facility proposed in the VTrans right-of-way is designed to exceed 24-hr detention time.

⁵ See cost section for more detail on planning level assumptions and costing analysis.

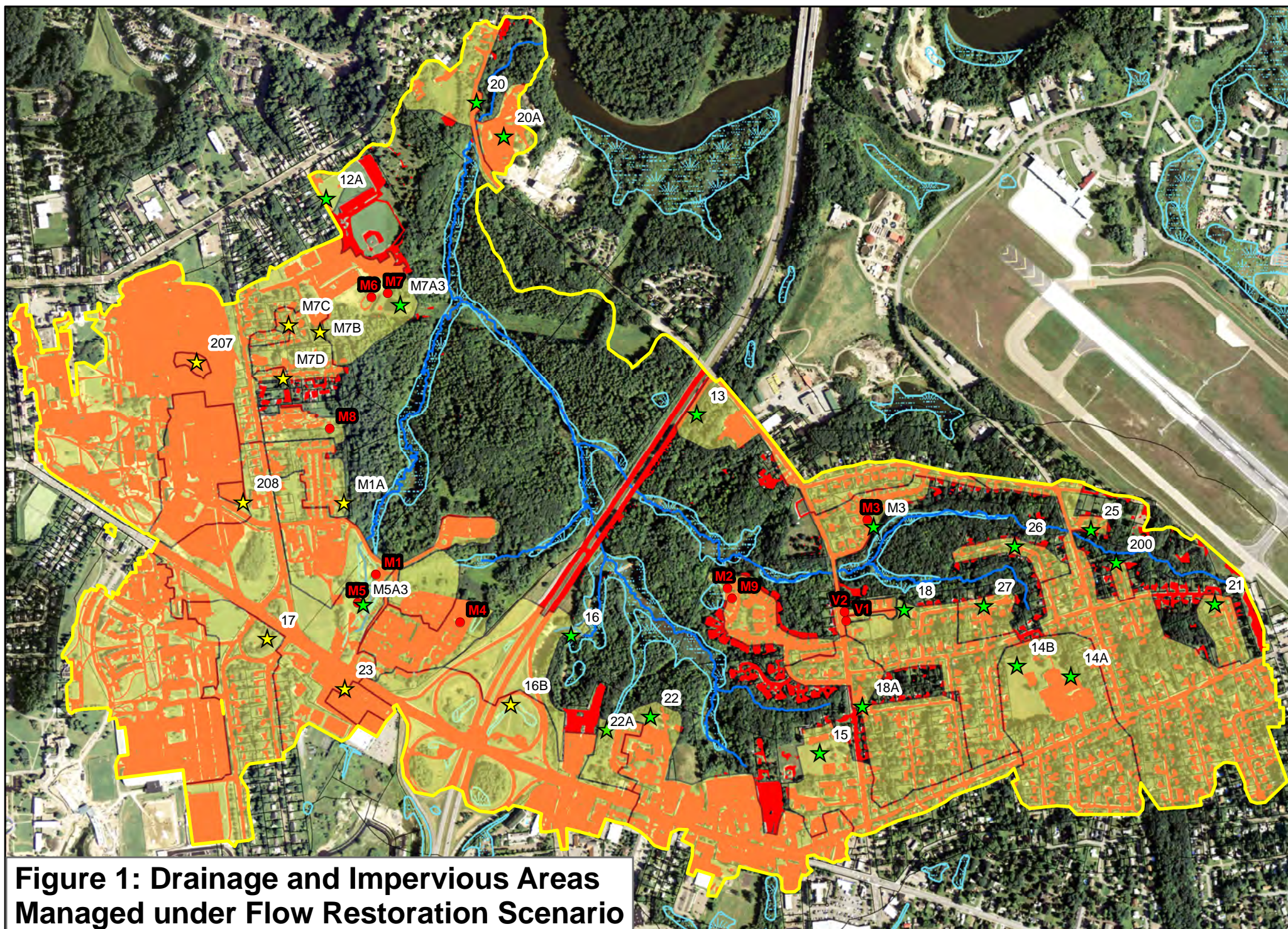


Figure 1: Drainage and Impervious Areas Managed under Flow Restoration Scenario

- Legend**
- ★ Primary Retrofit
 - ★ Secondary Retrofit
 - Retrofit DA
 - Existing BMP
 - stream
 - Watershed
 - Wetlands_SoBu
 - Impervious Cover

N
1,000 Feet

tce TRUDELL
CONSULTING ENGINEERS

Horsley Witten Group
Sustainable Environmental Solutions
30 Route 6A • Shelburne, VT 05482
Tel: 802.475.8800 • Fax: 802.475.1700 • www.horsleywitten.com

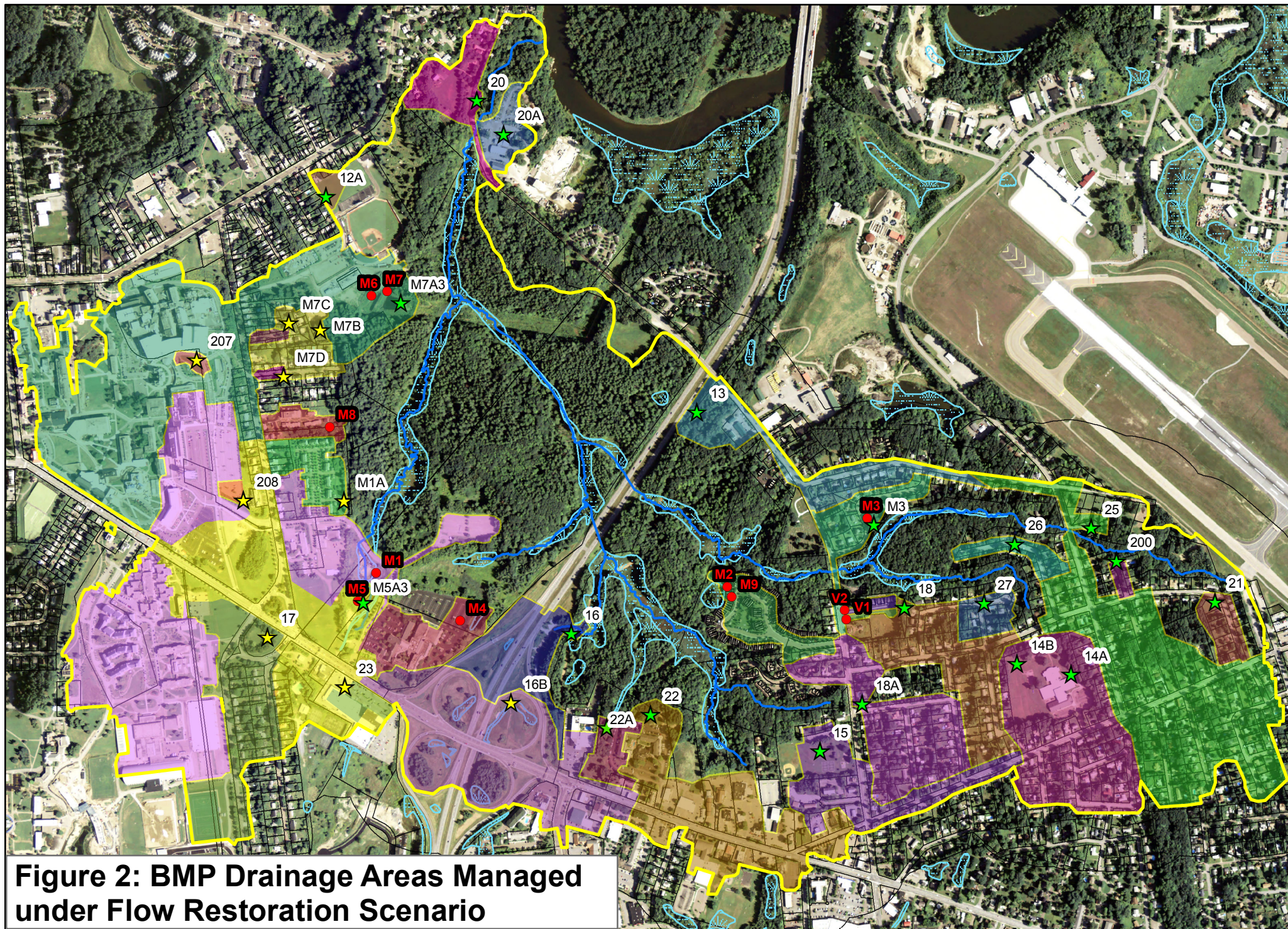


Figure 2: BMP Drainage Areas Managed under Flow Restoration Scenario

- Legend**
- ★ Primary Retrofit
 - ★ Secondary Retrofit
 - Existing BMP
 - Retrofit DA
 - stream
 - Wetlands_SoBu
 - Watershed
 - Parcels

N
1,000 Feet

tce TRUDELL
CONSULTING ENGINEERS

Horsley Witten Group
Sustainable Environmental Solutions
100 Route 1A • Sandwich, MA • 01963
Tel: 508-833-0900 • Fax: 508-833-3700 • www.horsleywitten.com



Figure 3. Colchester Ave. Proposed Watershed Expansion

Legend

	Colchester Ave Area		Existing Watershed Boundary
	Impervious Cover		

  Feet
100

 **TRUDELL**
CONSULTING ENGINEERS

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Sustainable Environmental Solutions
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General Conclusions

The restoration scenario presented here is not intended to represent the optimal implementation scenario proposed by the MS4s, rather it represents the maximum reduction all MS4s agree is achievable, regardless of cost considerations. Prior to moving forward with finalizing the flow restoration plan for Centennial Brook, the MS4s and the VT Agency of Natural Resources (ANR) may want to consider the following:

1. A detailed analysis was conducted by Chittenden County Regional Planning Commission in July, 2013 that refined the estimate of future, unregulated impervious cover to a more realistic estimate of 5 acres, rather than the 40 acres assumed in the TMDL. This change, if approved by ANR, would lower the high flow TMDL target from 63.0% to 51.5%.
2. Restoration activities other than the implementation of structural stormwater retrofits, such as tree planting, buffer enhancement, impervious cover reduction, or more stringent development requirements could potentially bridge the remaining gap for meeting the reduction target if a crediting mechanism was established.
3. Higher flow reductions are possible if surface detention time (center of mass) are relaxed in Centennial Brook; although modeling suggests that detention times >24 hrs for retrofits of existing and new ponds still cannot meet the 63% reduction target. If increased detention times were allowed, future permitting of proposed development projects draining to those retrofitted facilities would also need to be considered.
4. The proposed retrofits with the most influence on flow reduction modeled at the watershed outlet include: Best Western (#22 at 13.6% relative reduction); North Campus Pond (M7A3 at 7.7%); Chamberlain School (#14 at 5.9%); and Picard Circle (#25 at 4.3%). The East Campus Pond (M1) contributes to 13.4% of the achieved flow reduction, though no retrofit of this facility is proposed. The Main St. pond retrofit's (M5A3) relative reduction was 3.4%. These "regional" storage facilities manage more impervious cover than the smaller on-site BMPs, which have less of an individual influence on reductions measured at the watershed outlet. Based on the results of the VTBMPDSS, the revised 51.5% flow reduction target can be met by extending detention times of the UVM ponds beyond 24 hours; however, since over-detention in these existing facilities was reported by Krebs and Lansing to significantly reduce UVM's future development opportunities, this retrofit option is not considered practical. Regardless, the 63% target was not reached under any modeling scenarios.
5. A number of secondary BMPs (practices within the drainage areas of primary sites) were identified as backup options in case primary sites become infeasible or are down-sized. None of the secondary practices are able to completely replace the relevant primary practice, however. The I-89 clover-leaf (16B) comes the closest, but is about ½ as effective as the primary BMP proposed at I-89 outfall (16). Currently, these secondary practices are included in the proposed restoration scenario in addition to the primary facilities to show the maximum amount of flow reduction deemed achievable, regardless of cost. Removing the secondary facilities from the restoration scenario will likely result in a very modest change the flow reduction at significant cost savings.
6. The VTBMPDSS model runs for Centennial Brook do not fully depict expected increases in low flow despite a substantial increase in annual infiltration volumes from the proposed infiltration BMPs. Under the proposed restoration scenario, 94 acres of impervious cover are directed to infiltration practices designed to infiltrate the 1-year storm. Using the Burlington rainfall record, a rough analysis of recharge from the impervious area runoff should yield approximately 22 inches/year.

This recharge should augment streamflow by approximately 0.24 cfs across the entire flow duration curve; however, the model predictions of increase in low flow from infiltration practices are only 0.02 cfs (an 8% increase over baseline conditions).

7. The planning level estimate of overall capital costs for the proposed flow restoration scenario modeled is \$9,740,000.

The remainder of this memorandum provides more detailed information on the modeling analyses, BMP input information, and estimated construction costs. Additional supporting information submitted separately from, but in conjunction with, this memo includes:

- VTBMPDSS model runs for the revised baseline, the revised credit, and the proposed restoration scenario.
- GIS shapefiles used in each scenario, including updated impervious cover layer, BMP footprints, and other shapefiles created during this effort.
- HydroCAD models—created for all of the revised Credit BMPs and potential retrofits using HydroCAD version 10.00 for calibrating VTBMPDSS input;
- Spreadsheets—summarizing reductions, input variables, and cost estimates.

VTBMPDSS Modeling Analysis

The VTBMPDSS model is a continuous hydrological simulation model that estimates the effect of land use changes and stormwater BMPs on streamflow. This model was applied to the Centennial Brook watershed, which has a drainage area of about 1.4 square miles. The most important inputs to the model for this study are the GIS layers of land use, impervious cover, and soil, as well as the locations, configuration, and connections of the BMPs themselves.

Establishing Baseline Conditions

The ANR Baseline Scenario represents the watershed condition prior to the Centennial TMDL (2002), which in this case reflects six existing BMPs. In coordination with ANR, a Revised Baseline Scenario was created to address an issue discovered during subsequent modeling runs involving the application of BMPs with small drainage areas. Each time one of these on-site BMPs is added, the model creates a new routing connection that increases downstream flow and reduces times of concentration in the drainage area. This phenomenon can cause the VTBMPDSS model to underestimate the reduction potential of smaller green infrastructure (GI) practices and negates some of the potential benefits of BMP treatment trains. To accurately account for this effect, the Baseline Scenario was revised to incorporate virtual outlets (VOs) and drainage areas with “dummy” connections in the same manner as in the subsequently modeled flow restoration scenario. This adjustment did not alter flow paths in the Baseline Scenario, but did slightly increase Q03 base flows. Thus, slight increases in percent reductions over baseline conditions were achieved in the restoration scenarios.

FDC Statistics and Flow Reductions

The VTBMPDSS model outputs both summary files and complete records of hourly flows for any specified control points. The outlet is the primary control point (number 16 for this model). The outlet summary file (Init_Eval.out) provides a quick way to see the control point flows for Q95 and Q03 flows (cfs) from the current scenario. These numbers were used as a quick guide on performance.

For the final FDC flow numbers, ANR recommends that a separate FDC analysis be performed using only the last 10 years of the 12 year output record for the desired control point (Init_VirtualOutlet_16.out). The FDC spreadsheet was used to provide these numbers for all current scenarios. Only these FDC numbers are reported in this memo.

Additionally, ANR requires computation of the flow reductions percentages based on flow in cubic feet per second (cfs) not cubic feet per second per square mile (cfs/m). The logic is that additional watershed area would increase flow (in cfs) and require instream morphological changes that could be detrimental, like augmenting sediment load. The flow per square mile (cfs/m) might be unchanged and not reflect this impact. Only flows in cfs were reported in this memo.

Current Condition (Credit) Models

The ANR Credit Scenario reflects upgrades to four of the six ponds included in the baseline model to meet 2002 VT Stormwater Manual criteria. Updated ponds include: the East Campus Pond (M1), Sheraton Pond (M4); the North Campus Pond (M6) with sediment forebay (M7); and the Quarry Ridge Pond (M9) with sediment forebay (M2). The Queensbury Rd. Pond (M3) and the Main St. Pond (M5) remained unchanged from the baseline model. The ANR Credit Scenario was reviewed and revised to account for: 1) an error discovered in the HydroCAD and VTBMPDSS setup for the East Campus pond (M1), and 2) recent construction at Patchen Woods that added two vegetated swales (V1 and V2), increased impervious cover, and required slight changes to sub-watershed boundaries.

HydroCAD modeling of BMPs

HydroCAD models were set up for most of the proposed retrofits identified during field investigations in May, 2013. The Field Findings Memorandum (dated June 13, 2013) that documented procedures and feasible retrofit concepts has been revised to reflect subsequent changes to some of the retrofit concepts (see Revised Field Summaries Memorandum, dated October, 2013). The HydroCAD runs were saved as PDF files, marked up to show the relevant VTBMPDSS parameters used, and then the selected parameters were saved in a model input spreadsheet, thus providing full documentation of each VTBMPDSS model run. All HydroCAD models and the input spreadsheet are available for review. The following two modeling adjustments should be noted:

- HydroCAD models were based on the most updated impervious cover and soils data, which may differ slightly from what is being used in the VTBMPDSS model. ANR requested consistency in the GIS layers used for running model scenarios to ensure that results are comparable to baseline conditions; however, they agreed that the BMPs should be adequately designed using the latest data.
- Because of the differing methods that HydroCAD and the VTBMPDSS models aggregate runoff from soils and impervious areas and deal with flow lag times (time of concentration), the size of the HydroCAD designs for some infiltration practices (e.g., Jaycee Park (15) and Patchen Rd. (18A)) had to be increased to achieve maximum infiltration in the VTBMPDSS.

Flow Restoration Scenario

A number of restoration scenarios were modeled to compare various implementation options using 39 stormwater BMPs. In these scenarios, primary BMPs are defined as having an outlet directly to a stream while secondary BMPs drain to a downstream BMP. More details of the BMP concept summaries, based on GIS and field data, can be found in the revised "Centennial Brook Watershed: Retrofit Field Findings Summary Memorandum" (dated October, 2013). A few key model parameters used during the restoration scenarios include:

- The revised impervious cover used in the Revised Credit Scenario was updated slightly to account for new parking lots and buildings recently constructed/removed based on a visual inspection of the latest satellite images. Even though more recent impervious cover GIS layers were available, this approach was recommended by ANR since it allows direct comparison with the baseline scenarios without introducing differences between remote sensing technology used to develop the old and new impervious cover layers.
- The watershed boundary was changed in a few locations based on MS4 input and field verification. For example, the area north of University Avenue and west of the baseball diamond was removed because it is now connected to the combined sewer system. The UVM proposed expansion on the corner of Colchester Avenue and University Place was modeled as part of the restoration scenario presented here.
- All the stormwater practices, except for vegetated swales, were modeled as multistage ponds. The multistage pond allows the volume-stage relationship to be well represented, has more options for outlet control structures, and has all the controls represented in other model BMPs like infiltration or biofiltration. The multi-stage pond also has the added advantage in that it can be turned on/off or scaled with a multiplier (normally set to 1.0). The parameter allows the same network to be preserved for all flow restoration scenarios and is extremely useful for evaluating different scenarios and individual BMP performance.

Table 2 summarizes the base, credit, and restoration scenarios discussed above. Table 3 provides an accounting of some of the key input parameters of each proposed BMP used in the proposed restoration scenario.

Table 2. Summary of Modeling Scenarios

Model Scenario			Purpose	Q03 High Flow		Conclusion
				(cfs)	% Red.	
Pre-TMDL	ANR Base	Six pre-2002 BMPs, 2002 land use and IA GIS layers	What were the flows at the time the TMDL was established? These flows are the baseline from which restoration/treatment is measured.	27.2	--	We were able to successfully replicate ANR's model.
	Revised Base	ANR Base + virtual outlets, DAs, and network	Add "dummy" BMP connections to allow for more accurate comparison with restoration scenarios.	27.9	--	This is the new baseline to measure achieved flow reductions.
Current	ANR Credit	ANR Base + upgrades to some existing BMPs	What is the change in baseline flow with the retrofit of 4 of 6 existing BMPs to 2002 standards?	23.1	15.2%	We were able to replicate ANR's model.
	Revised Credit	ANR Credit + BMP revisions/addition	Revise current conditions by correcting model inputs on East Campus Pond (M1) and adding the Patchen Woods development.	23.2	14.8%	Corrections result in a slight decrease from ANR's prediction of the current reductions.
Proposed Restoration Scenario		All primary and secondary retrofits (see Table 3)	What is the max. flow reduction achievable if all feasible retrofits are implemented with UVM-designed retrofits of the Main St. (M5A3) and North Campus (M7A3) ponds and the Colchester Ave. expansion.	15.6	44.2%	Does not meet the revised 51.5% TMDL reduction target, and benefit of secondary practices probably not worth the additional cost.

Table 3. BMPs used in Flow Restoration Scenarios

Site ID	Site Name	BMP Type ¹	Class ²	DA (ac)	IA (ac) ³	% Difference in Q03 ⁴		Design Notes
						BMP Outlet	Watershed Outlet	
12A	University soccer field	IB	E	1.41	0.33	-100.0	0.0	--
13	Patchen Rd. depression	URC	P	14.06	5.07	-100.0	-1.2	Max. ponding depth=7'; Exfiltration = 2.41 in/hr
14A/B	Chamberlin School	URC	P	31.49	10.12	-100.0	-5.9	Field size: 97'(w) x 167'(l) x 3.5'(h); Exf. = 0.52 in/hr
15	Jaycee Park	DB	P	15.73	6.28	-100.0	-2.7	Field size: 87'(w) x 60'(l) x 3.5'(h); Exf. = 2.41 in/hr
16	I-89 outfall	DB	P	52.25	18.88	-26.4 ⁴	-2.1	Max det. time= 46.6 hr; max. ponding depth=12'
16B	I-89 cloverleaf (NE)	UDC	S	39.17	16.14	-83.0	-0.9	Max det. time=48.8 hrs; max. ponding depth=8'
17	Jug handle @ Spear & Main St. (east)	UDC	S	22.01	7.28	-74.9	-0.3	Field size: 144'(w) x 231'(l) x 3.5'(h)
18	Fielding Lane Condos	URC	P	18.74	5.48	-100.0	-2.3	Max. ponding depth=4'; Exf. = 2.41 in/hr
18A	Patchen Rd & Pine St	URC	P	20.41	6.00	-100.0	-1.8	Field size: 49'(w) x 81'(l) x 3.5'(h); Exf. = 2.41 in/hr
20	Grove St Parking Lot	URC	P	8.82	2.54	-100.0	-0.3	Field size: 30'(w) x 74'(l) x 3.5'(h); Exf. = 2.41 in/hr
20A	SD Ireland Property	URC	P	4.66	3.82	-100.0	-0.2	--
21	Dumont Ave (south)	URC	P	3.93	1.20	-100.0	-0.1	Field size: 21'(w) x 24'(l) x 3.5'(h); Exf. = 2.41 in/hr
22	Best Western Windjammer (N)	IB	P	29.25	21.68	-100.0	-13.6	Max. ponding depth=12'; Exf. = 2.41 in/hr
22A	Best Western Windjammer (W)	IB	P	4.09	1.24	-100.0	-0.5	Max. ponding depth=3'; Exf. = 2.41 in/hr
23A/B	Staples Plaza	UDC	S	2.50	2.43	-67.7	-0.2	Field size: 35'(w) x 259'(l) x 2.33'(h)
25	Picard Circle	URC	P	51.85	17.11	-86.7	-4.3	Field size: 49'(w) x 138'(l) x 3.5'(h); Exf. = 2.41 in/hr
26	Duval St	URC	P	3.57	1.18	-100.0	-0.1	Field size: 21'(w) x 24'(l) x 3.5'(h); Exf. = 2.41 in/hr
27	Clover St	URC	P	3.82	1.43	-100.0	0.0	Field size: 26'(w) x 31'(l) x 3.5'(h); Exf. = 2.41 in/hr
200	N Henry Court	URC	P	1.03	0.45	-100.0	0.0	Field size: 11'(w) x 24'(l) x 3.5'(h); Exf. = 2.41 in/hr
207	Fletcher Allen green space	Bio	S	0.89	0.85	-100.0	0.0	Bio surface area: 3,200 sf
208	Fletcher Allen parking lot	Bio	S	0.83	0.53	-100.0	-0.1	Bio surface area: 2,300 sf
M1A	Centennial Crt Apartments	IB	S	6.54	3.03	-100.0	-0.6	Max. ponding depth=4'; Exfiltration=0.52 in/hr

Site ID	Site Name	BMP Type ¹	Class ²	DA (ac)	IA (ac) ³	% Difference in Q03 ⁴		Design Notes
						BMP Outlet	Watershed Outlet	
M1	East Campus Pond	DB	E	80.30	49.34	-58.1	-13.4	Existing UVM design. Max. det. time= < 12 hrs. Stor. Vol. = 11.3 ac-ft
M2/M9	Quarry Ridge	DB	E	7.44	4.2	-59.7	-1.1	Max det. time= 12.5 hrs
M3A	Queensbury Pond (modified)	IB	P	8.99	4.17	-86.5	-0.8	Max. ponding depth=10'; Exfiltration=2.41 in/hr
M4	Sheraton	DB	E	9.81	6.70	-52.4	-0.2	Max det. time= 9.9 hrs
M5A3	Main St (UVM modified)	DB	P	64.15	26.59	-39.0	-3.4	UVM design. Max. det. time= < 12 hrs. Stor. Vol. =8.5 ac-ft; with smaller low flow orifice of 5.8" than existing
M6 / M7A3	North Campus (UVM modified)	DB	P	86.36	48.22	-46.3	-7.7	UVM design. Max. det. time= < 12 hrs. Stor. Vol. =21.5 ac-ft.; perm pool elevation 236.0, with smaller low flow orifice of 7.3" than existing and raised to 9-ft embankment
M7B	Open area east of Case Pkwy	URC	S	7.04	3.19	-100.0	-0.1	Field size: 40'(w) x 74'(l) x 3.5'(h); Exf. = 2.41 in/hr
M7C	Case Pkwy center island	Bio	S	0.86	0.50	-100.0	0.1	Bio surface area: 700 sf
M7D	140 East Ave residence	Bio	S	0.63	0.36	0.0	0.0	Bio surface area: 1,550 sf
M8	Burlington COOP	DB	E	3.73	1.62	-100.0	-0.4	Max det. time= 2hrs
V1	Patchen Woods	VS	E	0.48	0.32	-50.0	-0.3	
V2	Patchen Woods	VS	E	0.91	0.81	-100.0	-0.11	

¹ Bio=bioretention; DB=detention basin, IB= infiltration basin; UDC= underground detention chamber; URC=underground recharge chambers; and VS=vegetated swale

² P=Primary BMP; S= Secondary BMP that drains to a primary BMP; E=Existing practice (no modification)

³ Impervious area shown here is based on the most recent/ accurate information that was used to size potential retrofits and may not correspond exactly with GIS layers used in the VTBMPDSS model

⁴ Percent difference in high flows is negative when showing a reduction. The model was run with all BMPs turned on and then with individual BMPs turned off, one at a time, to quantify differences in flow and relative performance at the outlet of individual BMPs. Differences at each BMP outlet were determined by comparing the inflows and outflows. 100% represents no surface discharge; BMPS with less than 50% at the BMP outlet could be opportunities to enhance performance. Differences in flow at the watershed outlet are intended as a relative comparison of BMP effectiveness, but are not absolute or additive. Individual BMP values do not add up to corresponding total watershed reductions due to other losses in the system.

⁴ Relative performance for #16 appears low because #16B is already managing a large portion of the drainage area.

Estimated Project Costs

This section provides estimates of construction costs for the various stormwater retrofit facilities based on volume managed, the type of BMP, and the type of project site. The total cost for implementation of the restoration scenario presented here is \$9,740,000.

The cost estimates were developed based on the following assumptions and design decisions:

1. **Design Control Volumes** are based on the estimated runoff volume associated with the one-year storm event for underground systems or green infrastructure-type practices. Control volumes for large, above-ground infiltration or detention basins are based on the estimated runoff associated with the one hundred year storm event plus approximately two feet of freeboard volume. Underground systems and green infrastructure-type practices were conceptually designed as off-line practices that only accept runoff from the one-year event. Runoff volumes for all storm events were determined based on HydroCAD® model results that rely on the Soil Conservation Service (SCS) TR-55 and TR-20 hydrologic methods.
2. Table 4 summarizes **Unit Costs** for each BMP and **Site Adjustment Factors** that were derived from research by the Charles River Watershed Association and Center for Watershed Protection, as well as from our experience with actual construction. Underground detention chambers (UDC) and underground recharge chamber (URC) systems were typically designed using Stormtech SC-740™ chamber systems. A Stormtech SC-310™ system was used at Site 23A/B due to a shallow existing drainage system. Cost estimates for the retrofit sites described as “GI/URC” were calculated as bioretention treatment systems followed by Stormtech SC-740™ chambers for recharge benefits. The cost adjustment factors were used to account for site-specific differences typically related to project size, location, and complexity. Retrofits of existing BMPs, for example, generally cost less than new installations.

Table 4. Retrofit unit costs and adjustment factors

BMP	Base Cost (\$/ft ³)
Detention Basin	\$2
Infiltration Basin	\$4
Underground Chamber (infiltration or detention)	\$12
Bioretention	\$10
Green Infrastructure/ Underground Chamber Combo	\$22
Site Type	Cost Multiplier
Existing BMP retrofit	0.25
New BMP in undeveloped area	1.00
New BMP in partially developed area	1.50
New BMP in developed area	2.00
Adjustment factor for large aboveground basin projects	0.50

3. For certain retrofit locations, additional **Site-Specific Costs** were added to the construction costs. For example, Sites #13, #22, and M3A will require significant drainage or utility reconstruction. Site M5A3 will require ledge removal if constructed. Site M7A3 will require elevating the existing electric transmission lines to provide adequate clearance for the basin berm construction. Site-specific construction items are described in detail in the Retrofit

Summary Sheets provided as part of the Revised Field Findings Memo (dated October 14), except for the most recent retrofit concepts by UVM for M5A3 and M7A3, which were updated after submittal of the Revised Field Findings Memo. Table 3 provides information on the key design elements of M5A3 and M7A3.

4. **Base Construction Cost** is the product of the design control volume, the unit cost, and the site adjustment factor. Site-specific costs were added to this result for the applicable retrofit sites.
5. **Permits & Engineering Costs** were estimated at either 20% or 35% of the construction cost depending on the scale of the project. The largest projects (in terms of control volume) were estimated at 20% and the smaller projects at 35%. Certain large-scale projects that are likely to include high levels of engineering or permitting effort were assigned a 35% fee, despite their overall size.
6. **Land Acquisition Cost** was added to the total costs for facilities located on private, non-UVM properties. Retrofits that may require partial land acquisition fees were marked up by \$150,000; retrofits possibly requiring total land acquisition were marked up by \$300,000. These land acquisition estimates are considered to be place-holders at this time and may require adjustments based on current land values and the willingness of land owners to grant easements for the proposed drainage improvements. It was assumed that no land acquisition fees would be necessary for privately owned Sites 22, 22B, and 23A/B due to possible Residual Designation Authority (RDA) applicability. Site M1A was also not assigned a land acquisition fee due to possible existing agreements between UVM and the Centennial Court Apartments property management; however additional refinement of costs for UVM property may require inclusion of a land acquisition cost.
7. **Total Project Cost** is the sum of the base construction cost, permitting & engineering costs, and land acquisitions costs; it does not include operation & maintenance costs.
8. **Relative Cost** is described in terms of total project costs and represented by dollar signs. A project costing less than \$100,000 is given \$; a project between \$100,000 and \$250,000 is given \$\$; a project between \$250,000 and \$500,000 is given \$\$\$; and a project greater than \$500,000 is given \$\$\$\$.
9. **Costs per Impervious Acre** treated was calculated by dividing the sum of the construction costs and the permitting & engineering costs by the total impervious area directed to each BMP. Impervious areas used in this calculation are displayed in Table 3. Land acquisition costs and operation & maintenance costs are not included as part of this calculation.
10. **Operation & Maintenance** costs were estimated separately for each BMP, but are not included in the total construction costs. We assume that annual O&M is approximately 3% of project construction costs, with a cap at \$10,000.

Each of the numbered descriptions above provides clarification to the corresponding columns in Table 5. The spreadsheet used to develop Table 5 is provided separately as supporting information.

Table 5. BMP Cost Summary Table

Site ID	Site Name	BMP Type	Class	Design Control Volume ¹ (ft3)	Base Unit Cost ² (\$/cu.ft.)	Site Adjust. Factor ²	Site Specific Cost ³	Base Constr. Cost ⁴	Permits & Eng. ⁵	Land Cost ⁶	Total Project Cost ⁷	Relative Cost ⁸	Cost/ Imp. Acre ⁹	O&M ¹⁰
12A	University soccer field	IB	E	2,700	-	-	-	-	-	-	-	-	-	-
13	Patchen Rd depression	URC	P	66,800	\$4	0.25	\$25,000	\$91,800	\$33,000	\$150,000	\$280,000	\$\$\$	\$25,000	\$2,800
14A/B	Chamberlin School	URC	P	35,200	\$12	1.50	\$0	\$633,600	\$127,000	\$0	\$770,000	\$\$\$\$	\$76,000	\$10,000
15	Jaycee Park	DB	P	11,300	\$12	1.50	\$0	\$203,400	\$72,000	\$0	\$280,000	\$\$\$	\$48,000	\$6,200
16	I-89 outfall	DB	P	566,000	\$2	1.00	\$0	\$1,132,000	\$227,000	\$150,000	\$1,510,000	\$\$\$\$	\$72,000	\$10,000
16B	I-89 cloverleaf (NE)	UDC	S	320,000	\$2	0.50	\$0	\$320,000	\$112,000	\$0	\$440,000	\$\$\$	\$27,000	\$9,600
17	Jug handle @ Spear & Main St.	UDC	S	73,000	\$12	1.50	\$0	\$1,314,000	\$263,000	\$0	\$1,580,000	\$\$\$\$	\$217,000	\$10,000
18	Fielding Lane Condos	URC	P	21,700	\$4	1.00	\$0	\$86,800	\$31,000	\$300,000	\$420,000	\$\$\$	\$23,000	\$2,700
18A	Patchen Rd & Pine St	URC	P	8,600	\$12	1.50	\$0	\$154,800	\$55,000	\$150,000	\$360,000	\$\$\$	\$35,000	\$4,700
20	Grove St Parking Lot	URC	P	4,800	\$12	2.00	\$0	\$115,200	\$41,000	\$0	\$160,000	\$\$	\$62,000	\$3,500
20A	SD Ireland Property	URC	P	28,700	-	-	-	-	-	-	-	-	-	-
21	Dumont Ave (south)	URC	P	1,100	\$12	1.50	\$0	\$19,800	\$7,000	\$0	\$30,000	\$	\$23,000	\$600
22	Best West.(N)	IB	P	181,000	\$4	0.50	\$50,000	\$412,000	\$145,000	\$0	\$560,000	\$\$\$\$	\$26,000	\$10,000
22A	Best West. (W)	IB	P	30,000	\$4	0.50	\$0	\$60,000	\$21,000	\$0	\$90,000	\$	\$75,000	\$1,800
23A/B	Staples Plaza	UDC	S	11,600	\$12	2.00	\$0	\$278,400	\$56,000	\$0	\$340,000	\$\$\$	\$139,000	\$8,400
25	Picard Circle	URC	P	14,700	\$12	1.50	\$0	\$264,600	\$53,000	\$0	\$320,000	\$\$\$	\$20,000	\$8,000
26	Duval St	URC	P	1,100	\$22	1.50	\$0	\$36,300	\$13,000	\$150,000	\$200,000	\$\$	\$42,000	\$1,100
27	Clover St	URC	P	1,700	\$12	1.50	\$0	\$30,600	\$11,000	\$150,000	\$200,000	\$\$	\$30,000	\$1,000

Site ID	Site Name	BMP Type	Class	Design Control Volume ¹ (ft3)	Base Unit Cost ² (\$/cu.ft.)	Site Adjust. Factor ²	Site Specific Cost ³	Base Constr. Cost ⁴	Permits & Eng. ⁵	Land Cost ⁶	Total Project Cost ⁷	Relative Cost ⁸	Cost/ Imp. Acre ⁹	O&M ¹⁰
200	N Henry Court	URC	P	600	\$22	1.50	\$0	\$19,800	\$7,000	\$0	\$30,000	\$	\$60,000	\$600
207	Fletcher Allen green space	Bio	S	3,700	\$10	1.00	\$0	\$37,000	\$13,000	\$0	\$50,000	\$	\$59,000	\$1,200
208	Fletcher Allen parking lot	Bio	S	2,700	\$10	1.00	\$0	\$27,000	\$10,000	\$0	\$40,000	\$	\$70,000	\$900
M1A	Centennial Court Apts.	IB	S	30,800	\$4	1.00	\$0	\$123,200	\$44,000	\$0	\$170,000	\$\$	\$59,000	\$3,700
M3A	Queensbury (modified)	IB	P	26,700	\$4	0.25	\$25,000	\$51,700	\$19,000	\$150,000	\$230,000	\$\$	\$24,000	\$1,600
M5A3	Main St (UVM modified)	DB	P	370,900	\$2	0.50	\$100,000	\$470,900	\$95,000	\$0	\$570,000	\$\$\$\$	\$22,000	\$10,000
M7A3	North Campus (with extra DA)	DB	P	1,008,000	\$2	0.25	\$100,000	\$604,000	\$121,000	\$0	\$730,000	\$\$\$\$	\$16,000	\$10,000
M7B	Open area east of Case Pkwy	URC	S	6,300	\$12	1.50	\$0	\$113,400	\$40,000	\$0	\$160,000	\$\$	\$38,000	\$3,500
M7C	Case Pkwy center island	Bio	S	1,000	\$10	1.50	\$0	\$15,000	\$6,000	\$0	\$30,000	\$	\$42,000	\$500
M7D	140 East Ave residence	Bio	S	1,800	\$10	1.50	\$0	\$27,000	\$10,000	\$150,000	\$190,000	\$\$	\$103,000	\$900

See preceding text for footnotes.

References

- Charles River Watershed Association. 2012. Stormwater management plan for Spruce Pond Brook subwatershed. Prepared for the Town of Franklin, Massachusetts.
- Chittenden County Regional Planning Commission. July 18, 2013. Impervious Surface Analysis in the Centennial Brook Watershed. 3 pp.
- Harrington, Bruce W. 1987. Design procedures for stormwater management extended detentions structures. MD Department of the Environment, Sediment and Stormwater Division.
- Horsley Witten. October, 2013. Centennial Brook Watershed: Retrofit Field Findings Summary Memorandum (revised). 8pp.
- Horsley Witten. February 2012. Centennial Brook Watershed Flow Restoration Plan Development: Phase I Findings Memorandum. 17 pp.

APPENDIX 9

BARTLETT BROOK EXPIRED PERMITS LIST

Table A-9: Bartlett Brook Expired Permit Discharges and Proposed Retrofits

BMP in BMPDSS Model	Permit Number	Project Name	RDA/Other ¹	Permit Issued	Existing Manner of Discharge ²	Proposed System Upgrades under FRP ³
No Channel Protection Volume (CPv) BMP covered under Permit	1-0202.XXXX	Meadowwood at Spear	n/a	6/1/1976	CB	Drains to proposed Kearsi Lane BMP (Infiltration Gallery)
	1-0665.XXXX	Pillsbury Manor	n/a	9/30/1988	GS, RS, ST	Proposed Underground detention chamber assessed. Determined not necessary to meet FRP targets.
	1-0705.XXXX	Freedom Nissan	6342-9030	5/23/1988	CB, GS	No retrofit proposed. System currently covered under RDA permit.
	1-0734	Champ Car Care	n/a	11/29/1988	CB, GS	Drains to proposed BBTS Expansion Project (Wetland Pond)
	1-1134.XXXX	Freedom Nissan	6342-9030	5/10/1993	OF	No retrofit proposed. System currently covered under RDA permit.
	1-1220.9908	Allen Rd Community Care	n/a	5/12/1996	CB, (2)ST	Proposed Infiltration Basin assessed. Determined not necessary to meet FRP
	1-1291.0112	US Route 7 Expansion	5625-9010	12/20/2002	CB, OF	Covered under 5625-9010. Portion of coverage area drains to proposed BBTS Expansion Project (Wetland Pond), and a portion drains to proposed Shelburne Rd. Project (Detention Chamber)
	2-0153.XXXX	WESCO Distributors	n/a	4/26/1983	CB	Drains to proposed BBTS Expansion Project (Wetland Pond)
	2-0180.XXXX	Shelburne Plastics	n/a	9/26/1983	GS	Drains to proposed BBTS Expansion Project (Wetland Pond)
Channel Protection Volume (CPv) BMP covered under Permit	3121-9010	Willie Racine Jeep Isuzu	n/a	11/24/2003	GS, (2)DP, CB	Drains to proposed BBTS Expansion Project (Wetland Pond). Limited space to manage on-site.
	3017-9010	IDX Headquarters - 25 GMD	n/a	6/2/2003	IB	No retrofit proposed. Current system meeting VT 2002 SWMM standard for CPv.
	1-1404.9912	Irish Farms Residential Subdivision	n/a	5/31/2000	CB, (3)DP, GS	Irish Farms Pond Retrofit: Upgrade Pond B to gravel wetland, and new outlet control for Pond C.
	1-1372.9905	Staybridge Suites & Harbor Sunset Hotel	6296-9030	9/1/1999	CB, ST, DP, (2) IG	Proposed alternative option to route upper portion of Staybridge runoff to the Holiday Inn BMP rather than upgrade existing detention pond.
	1-1155.9806	Pinnacle at Spear	n/a	4/21/1999	CB, (2)DP, OF	Upgrade Pond A and B with new outlet control and increase storage.
	1-0949.XXXX	Bouyea-Fassetts Building	6281-9030	6/6/1990	OF, IB	No retrofit proposed. System currently covered under RDA permit.
	1-0523.XXXX	Champ Carwash	6280-9030	11/3/1987	GS, OF, DP	No retrofit proposed. System currently covered under RDA permit.
	2-1073.XXXX	Howard Johnson's	6297-9030	12/20/1985	DW, CB, OF, ST	Portion of coverage area drains to proposed Holiday Inn Project (Infiltration Gallery)
	2-0261.XXXX	Overlook at Spear/Summit at Spear	n/a	4/17/1985	CB, GS, (4)DP	Neighborhood GSI Retrofit: Propose 6 collections of biofilters or infiltration basins in the ROW, within the drainage area for the 4 on-stream ponds covered under #2-0261. Retrofit of on-stream ponds determined less feasible than distributed GSI retrofit.
	2-0120.XXXX	Bay Court/Harbor Heights/Keari Rd	6294-9030 & 6294-9030.1	8/11/1982	CB, (4)SF	Drains to proposed Kearsi Lane BMP (Infiltration Gallery)

* Table Originally Prepared by Emily Schelley (VT DEC, last revised 1-31-14), Revised by WCA (2014).

¹ RDA: Residual Designation Authority- Private Permittees requests to have their expired stormwater system covered under an RDA permit, which overwrites their expired permit

² Manner of Discharge: CB: Catch Basin, GS: Grass Swale, RS: Retention Swale, ST: Settling Tank, OF: Control orifice, IB: Infiltration Basin, DP: Detention Pond, DW: Dry Well, IG: Infiltration Gallery, SF: Sand Filter

³ Expired permit retrofits were determined based on direct benefit to the Flow Restoration Targets. Expired permits with a CPv(extended detention of the 1-year design storm) BMP were assessed for retrofit opportunity, and if the flow reduction benefit was determined negligible, a retrofit was not proposed. It was determined beneficial to route several expired permit systems to a larger retrofit project, rather than retrofit the existing system on-site.